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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and Subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 40, Norfolk Street, Strand, London, W.C. 2, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Corresepondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

PEASANT INVESTIGATIONS AT THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD

The total contribution of peasant farmers to world production is considerable, as witness the cocoa crop of the Gold Coast approaching a quarter of a million tons, the Nigerian groundnut crop of around three hundred thousand tons, and the cotton crop in Uganda of two hundred and seventy thousand bales. In addition these populations are largely self supporting as regards food, albeit at a relatively low level in most cases. In the West Indies, peasant agriculture has been concerned mainly with the production of food crops, and Governments have devoted much time and money to establishing small holding settlements.

It has become fashionable to decry peasant production as wasteful and inefficient, and to assume that large scale mechanisation, combined with specialised cropping and collective farming, is superior technically, and offers a suitable alternative, with surplus population no longer required for primary production becoming absorbed industrially. Whether the peasants themselves wish to be so organised, whether the social price of such a revolution is too high, whether it is sound in this uncertain world to tie up a peoples' economy to the world's markets and particularly to the oil and tractor industries with all the difficulties of maintenance and supply, or whether better land usage and a higher standard of living can be achieved with less social disturbance — and therefore less unhappiness — through the medium of more evolutionary methods, involving more education in the widest sense, with intensive production and specialisation in small units as the aim, are important issues requiring clarification. Unquestionably soil fertility is not being maintained at present and rapid improvement is vital, but in order to plan wisely it is essential to have available basic information. Such information is notoriously lacking on the subject of peasant agriculture especially in the West Indies.

This fact is emphasised in reports on economic surveys of peasant agriculture in the West Indies*, which have been carried out particularly in relation to land settlement, by Professor C. Y. Shephard and Dr. A. L. Jolly

* Shephard, C. Y., "Peasant Agriculture in the Leeward & Windward Islands."

of the Economics Department of the College. The bulk of the people in the Colonial Empire are peasants and it would seem fitting and desirable from a teaching point of view that the Imperial College, where senior staff for the Colonial Agricultural Service receive advanced training, and where research into the production of such plantation crops as bananas, cocoa, and sugar is already centred, should also carry out research in tropical agriculture on a peasant scale.

In 1946 the College authorities decided to start a comprehensive investigation of the subject and a Peasant Investigation Committee was formed under the Chairmanship of the Professor of Agriculture. The members of the committee included the Director of Agriculture, Trinidad, the Principal of the College, the Professor of Economics and the Senior Lecturer in Economics, the Professor of Chemistry, with the Senior Lecturer in Agriculture as Secretary. The committee, with various additions to its membership, has held numerous meetings since its inauguration. The meetings of the committee have been regarded as a forum for the discussion of peasant agriculture and it is hoped that eventually the investigation may develop into a bureau of information upon the subject. Though West Indian circumstances, particularly in relation to land settlement, have necessarily received most consideration, the ultimate wider significance of the findings has not been lost sight of. Minutes of the meetings of the Committee have been widely circulated and correspondence which has arisen as a result gives proof of widespread interest in the subject.

The investigation has centred round the information to be obtained from a series of experimental unit holdings established on the College Farm; the unit is a family consisting essentially of a man and wife. So far, only single units have been contemplated in detail but the possibility of developing compound co-operative units at a later stage is envisaged. In order to confine the investigation to reasonable bounds and to obtain information of a comparative nature, it has been found desirable to introduce certain arbitrary standards. Basic matters of policy are threshed out by the Committee, and some of the conclusions are shown in the following short digest of the minutes.

Mixed farming is to be followed on all holdings and peasants must live on their land. The aim is to find what, if any, combination of land, crops and livestock, with the labour provided by a man and wife, will give a reasonable return for capital invested, and will give regular remunerative employment throughout the year with a well distributed income. Although it has frequently been stated that the final criterion must be hours of work and pounds of produce, subsistence aspects of the investigation have not yet received much attention; such tests as have been applied have been in terms of dollars and cents — cost of labour at standard Government rates, and value of produce at local wholesale rates. The system of farming must maintain soil fertility and the unit, or combination of units, must be capable of reproduction in numbers on a land settlement scheme. Fertilizers are supplied at cost as required, and concentrated cattle foods in relation to milk yields. The cost of establishment of each type of holding is important, so that Governments contemplating land settlement schemes may be given precise information on this point. Distinction must be made between "build-up" and "built-up" holdings, inadvertently all present holdings are "built-up" i.e. they were fully established before occupation. Production and management problems have been investigated so far, not marketing. Farming systems are reviewed annually by the Committee and modified as thought fit. When a stage is reached where no further modifications of a holding are possible without radically altering its nature, the system will either be ready for demonstration or it will be abandoned.

Uncertainty regarding funds hampered early developments. A sum of two hundred pounds was advanced privately on loan to the College to enable an immediate start to be made, and in 1947 a grant of £1,200 was made available for capital expenditure from Colonial Development and Welfare funds through the good offices of the Agricultural Adviser to the Comptroller of Development and Welfare for the West Indies. The investigation has proved to be considerably more complicated than was envisaged at the outset, which suggests a reason for the general lack of critical information. The establishment of a series of up to sixteen experimental unit holdings was contemplated in early discussions, so far it has been possible to establish and manage only four; one was laid down in 1946 and three more in 1947; it is hoped to increase this number shortly when a full time executive officer is appointed. It should be noted that not only is peasant agriculture under review but the technique of carrying out such an investigation has of necessity been the subject of experiment by methods of trial and error. The problems are human as well as technically agricultural. The investigation has shown many gaps in our knowledge of agriculture on a peasant scale and indicated the need for facilities to carry out individual experiments to support the investigation.

Of the four established holdings, three have been planned on a comparative basis ; they are mixed arable holdings with varying combinations of arable crops, fodder grass, and livestock. The fourth holding is an irrigated market garden unit. Holding I is a manual unit of 3.2 acres stocked with one dairy cow; approximately two acres are cropped in a rotation with sugar-cane and yams as the main cash crops, and sweet

potatoes, maize, soya beans and pigeon peas as subsidiary crops; rice is grown on a separate irrigated area; one acre is cropped with Guatemala grass and elephant grass as fodder for the cow. Holding II differs from Holding I in that it has half the area of cropped land, twice the area of fodder and three cows instead of one. Holding III is an ox plough unit of 4¾ acres, with half as much arable and fodder again as Holding I, two dairy cows and one working ox. Holding IV is a manual, irrigated market garden unit of 1½ acres, production is concentrated on cabbage and cauliflower, lettuce and melongene, alternated with elephant grass; the stocking consists of one cow. Holdings I, II and III are expected to be self-supporting as regards organic manure; Holding IV will have to purchase manure from such a holding as the dairy unit now being planned.

The "peasants" are East Indians; they receive wages at local Government rates and are given an annual bonus of approximately $150 as an incentive. In addition a house is provided rent free and a bottle of milk is allowed each family a day. To avoid overcapitalization the cheapest and simplest buildings have been erected compatible with reasonable comfort and health requirements. Local building materials are used and the peasants maintain the buildings in repair.

Whatever the ultimate future of peasant agriculture, it is certain that progress can be made only as a result of a scientific approach to the subject, that is by study and experiment leading to Government policy based on fact rather than opinion. The present investigation has not proceeded far enough yet to yield results of any significance, a good start has been made with what has proved to be a complicated experiment, and a satisfactory system of recording has been devised; future developments depend upon finding suitable staff and the provision of adequate funds and facilities.

C.W.L.

A NOTE ON THE EFFECT OF CONTINUOUS LIGHT ON THE FLOWERING OF PADI

BY

E. G. Benson and D. B. Murray
(Department of Agriculture, Trinidad).

In Trinidad it is the practice of some of the Oil Companies to get rid of waste natural gas by leading it through a 3 or 4 inch pipe 25 to 30 feet high and burning it at the top as a flare. This produces a continuous bright flame 6 to 8 feet high, visible at night for many miles.

Early in 1947, one of the Companies erected such a flare on the edge of a field in which swamp padi is usually grown during the latter half of every year. Padi was planted in the area during the months of July and August and flowering was expected to take place in October. In the vicinity of the flare, however, the emergence of the flowering panicles from the sheathing leaves did not occur as was normally expected. The farmers concerned reported the matter to the Oil Company, who in turn communicated with the Agricultural Department.

Investigation in the field disclosed further that where a tree had thrown a shadow from the flare across the padi, the crop was flowering normally and as a result the extent of the shadow could easily be traced. The overall condition was, however, complicated by the fact that the padi was planted in a series of small plots at different times, and by existing local differences in water supply. These factors led to a patchy growth of the crop.

Most of the padis grown in Trinidad appear to ripen during the period of shortening days. It was evident that the light intensity of the flare at night was sufficient to upset the normal photoperiodic response of the plant, and to arrest the reproductive stages of flowering and fruiting, except in those areas of the field where the crop had been shaded from the flare at night. The effect was noticeable at least 300 yards from the flare, at which distance the light intensity must have been very low. At this distance even low obstacles cast long shadows and in these long shadows, padi was flowering normally.

As a result of this investigation, the Company readily agreed to extinguish the flare and once this was done, in early November, the padi rapidly came into flower and the crop was harvested some 4 to 6 weeks late.

SOIL CONSERVATION AND LAND USE PLANNING IN NATIVE RESERVES IN SOUTHERN RHODESIA

BY

W. E. Bond, B.A. (CANTAB.), A.I.C.T.A.

Introduction

Soil conservation can only be seen in its true perspective when considered together with wise land use, of which it is both a part and a consequence. As Bennett states: "The guiding principle of the Soil Conservation Service in planning land use has always been the effective prevention and control of soil erosion".

Conversely, soil erosion is a disease of the surface of the earth, caused by misuse of the land, so that in order to appreciate the problem a brief description of the human, economic, climatic, soil and ecological factors involved must be given and the extent to which erosion had proceeded before preventive and control measures were undertaken briefly described.

Extent and Main Causes of Soil Erosion in Native Reserves

Native Reserves were set aside in 1920 under an Order-in-Council "for the sole and exclusive use and occupation of the native inhabitants". They are areas for the most part which were already inhabited by natives at the time of the occupation — a little more than 50 years ago. But the numbers of natives then were few, and estimated in 1901 to be 487,000, and as a result of the rinderpest epidemic, the numbers of their cattle were even fewer — less than 44,000. Since then, with the end of tribal warfare, and the control of epidemic diseases of man and his cattle, these numbers have increased to over 1,084,000 humans and over 1,205,000 cattle, with large numbers of donkeys, sheep and goats besides. In addition, as land in the European areas has been occupied for farming or ranching, more natives have been moved into the reserves. However, compared with other parts of Africa, few of the 96 reserves are densely populated; only eight reserves have less than 10 acres of arable land per family. But many are overstocked. Allowing 10 acres per beast in the high rainfall areas plus 33 1/3 and 66 2/3 more in the medium and low rainfall areas respectively, 42 of the 96 reserves are overstocked.

The native people own over 100,000 ploughs, and much of the ploughing is up and down hill — partly deliberately to drain lands liable to waterlogging and make them more suitable for maize, but largely because it is less trouble to let the oxen walk up or down hill rather than guide them across the slope.

After hand cultivation, ploughing is easy, and huge acreages are ploughed up — in some reserves every square yard of land, except for rock and very stony ground. Much of the ploughing is done by women and children as many of the able-bodied men are away at work on mines, in towns, a few on farms and some away in South Africa. A mixture of maize, millet, groundnut and pumpkin seeds are broadcast behind the plough, and the acreage planted is far greater than the women and children can keep free of weeds. No manure of any kind is used. After a few years, when yields become very low and weeds more numerous, a new area is ploughed up and the old lands left to go back to grass and bush and, as most of the trees have only been cut down waist high, they grow again very rapidly.

Vleis are ploughed up for rice and wheat, and fertile damp places and the margins of water courses are planted with early maize.

As the population increases, the periods of fallow become less and, as maize becomes more popular, it is grown year after year on the same land. Some areas are severely infested with Witchweed (Striga sps.). The scanty humus content of the soil is rapidly exhausted and many lands become badly gullied. But ploughing and planting continues right into the gullies themselves so that these become larger year by year.

Generally, reserves are broken, often mountainous areas, and the slope of cultivated lands is mostly 3% and greater. The soils are sandy, mostly derived from granite, and often comparatively shallow. The natural vegetation is mostly an open forest of small trees and bushes with a sparse ground cover of grass and herbs. Except in low-lying places, the humus content is low, and the top soil is only 4" deep. The top soil, and the subsoil to an even greater degree, is highly erodible.

The climate is extreme — shade temperatures in summer frequently rise to 90° F. each day for long periods at a time, and sometimes go to over 100° F. during the hot season before the rains. In winter, frosts occur frequently at night from May to August. Evaporation is intense and the soil, apart from vleis, dries out completely to a great depth for months at a time. Rain falls only in summer, that is, from November to March, and during a normal year a number of falls of very high intensity may be expected in all localities. The average rainfall in different reserves varies from 10" to over 45" per annum, but the great majority of the native population live in areas with rainfall averages of between 20" to 35". Actual annual rainfall at any one station is frequently as little as half or as much as double the average. Rainfall intensities are very high. Over a period of 10

years, at both Salisbury and Bulawayo, more than 30% of the total rain fell at rates exceeding 1″ per hour (1). The number of rainy days per year in most areas is small — usually less than 80. The altitude varies from below 2,000 feet to over 8,000 feet, and 24% lies over 4,000 feet (2). Rainfall, generally speaking, increases with altitude, but at the lower altitudes a greater proportion of the rain falls in the form of violent thunderstorms. Most of the native population live in areas above 3,000 feet and below 5,000 feet above sea level.

In many years, after a period of heavy rain during January or February, the soil becomes saturated, so that further heavy falls of rain result in an almost 100% run-off.

In order to control ticks and prevent outbreaks of East Coast Fever and other tick-born diseases, dipping at from fortnightly to monthly intervals is compulsory. Dip tanks were constructed on the banks of rivers and streams so as to be near water. The heavy trampling of sloping ground by large numbers of cattle has destroyed the natural grass cover, and severe erosion of the bare soil has resulted. Owing to natural increase, from 2,000 to 5,000 head of cattle are now dipped at many tanks. The movement of large numbers of cattle at regular intervals over long distances has produced cattle tracks which have resulted in deep gullies on sloping ground.

The control of disease and desire to own cattle regardless of age, size or quality, has resulted in a huge increase in numbers and consequent destruction of the vegetation and severe trampling and erosion around kraals, on the banks of rivers and streams, and around wells and boreholes.

The herding of cattle is left more and more to young children, and now that they go to school the cattle are frequently not let out of the kraals until mid-day and are kraaled again long before nightfall, so that the grazing period is restricted, and the areas within half a mile or so of the kraals become badly tramped out.

Apart from natural causes, such as rainfall, water supplies, soil, etc., economic factors influence the distribution of population in native reserves. Grain, especially maize, and manpower and, to a lesser extent, even cattle and other livestock, are more valuable in proportion to their nearness to, or ease of, communication with the large centres of European population ; hence, in almost every reserve, there are one or more areas where the population is concentrated to a far greater extent than elsewhere. In such areas — usually near the rail-head, main road or mineral belt, the majority of the able-bodied males are away working most of the time and their wives and families, and old people, are left to do most of the farming and to care for the livestock. Here the standard of farming is lower than in the more remote areas, where the people are more dependent on the food and cash crops they grow. But, even though the men are away most of the time, they still cling to their reserves as a home for their families and a place to go and live in their old age. These men, who may be absent from their reserves for years at a time, accumulate wealth in the form of cattle which are held in trust for them by their kraal heads, so these areas are not only heavily populated but also invariably overstocked to a serious degree.

In the reserves which lie from 12 to 24 miles — sometimes more — from Salisbury, Bulawayo, Gwelo and Umtali, there are areas which are really dormitory suburbs where natives in permanent employment have their homes and cycle to and from work each day or return home every week-end. Yet they still plough lands and plant crops and own cattle. Erosion due to bad farming and overstocking in these areas is often very serious, and the breakdown of tribal control, and often family life as well, makes land use planning under existing legislation a difficult problem.

Maize is taken to mills to be ground and the meal is brought back to the kraals on wooden sleighs made from a V-shaped forked branch of a tree. Sleighs are used to take grain to the stores for sale and to bring back cloth and goods. They are used to carry manure to the lands and water up from the streams and rivers when wells and nearby surface waters dry up, and sleigh tracks are one of the greatest single causes of gullies.

Roads mostly follow existing sleigh tracks and paths and are not surveyed or graded and, especially at the approaches to rivers and streams, have frequently become great dongas. Funds for the construction and maintenance of roads in reserves are limited to at most a few shillings a mile, with the result that, as soon as a road becomes a gully, a diversion is made simply by cutting a new track through the bush. Worse still, when money is available, it is spent in digging deep, narrow drains parallel to the road, regardless of the slope. These scour out into deep gullies, sometimes in the space of a single year.

Brief History of Land Use Planning and Soil Conservation to Date

The first steps to educate reserve natives in correct land use were taken twenty years ago by the Government when two demonstrators were posted, one to Gwaai Reserve in Matabeleland, and one to Chinamora Reserve in Mashonaland. They had been trained to show the people, by

(1) Peak, J.S., Director Meteorological Services : Unpublished data.

(2) Report of Commission to enquire into the preservation, etc., of the natural resources of the Colony : p. 5. Salisbury, S. Rhodesia, *C. S. R.* 40/1939.

persuading a few of the more progressive among them to follow their advice, how to grow better crops than had ever been seen before under the old system of shifting cultivation. Their advice was to stump and winter-plough the lands, to use manure from the cattle kraal, and continue to use the same land over and over again by practising crop rotation ; to cultivate and row-plant their crops and keep them well weeded. Eleven natives followed their advice and reaped an average of over 12 bags of grain to the acre as compared with little more than two bags on neighbouring lands. At that time dung was left to accumulate year by year in the kraals until the mound became so high that a new kraal had to be made nearby. Manure could be had for the asking. In 1946, 20 years later, there are over 20,000 natives in reserves who are *known* to be farming well and getting yields of grain which average throughout the country from 8 — 10 bags per acre as against little more than one bag to the acre on neighbouring lands ploughed and planted with a mixture of crops behind the plough, not manured and scarcely weeded. Large numbers besides have learnt the use of manure, and in many reserves today kraal manure cannot even be bought ; the people refuse to sell ; it is too valuable.

But so long as the shifting of lands, and even kraals, from place to place every few years was the order of the day, few would go to the trouble of thoroughly stumping lands and manuring them. And as the population increased, the difficulty of grazing cattle in summer on small patches of fallow land scattered about among lands under crops became insuperable and led to constant litigation due to damage to crops by cattle. In 1929, after much persuasion, one sub-chief, 13 headmen and their 1,224 families in Selukwe reserve, agreed to group all their lands together in one area and set aside the balance as permanent grazing for their cattle. This was the beginning of the centralization of arable lands. These 14 headmen and their people were the only natives from whom buyers bought cattle at the next sale and, due to their condition, the prices paid were the highest ever known in Selukwe. The next year the big chief and all his headmen demanded that the whole reserve of 150,000 acres be centralized. This was done, and the centralization extended to other reserves until, by 1946, over 9,400,000 acres in 40 reserves had been centralized and surveyed into arable and grazing areas.

Centralization has made possible a more settled and civilized way of life. Suitable belts for habitation are surveyed along the boundaries of the centralized arable areas, and community demonstrators teach the people how to make both green and burnt bricks and to build permanent houses to replace the old, disease-infested, white-ant-ridden pole and dagga huts. From 1933 to 1946, over 100,000 improved types of houses have been built in reserves, besides community halls, schools, churches and grain bins (3).

However, it became apparent that demonstration and persuasion alone were not making sufficient progress by themselves in achieving proper land use, but that the destruction of natural resources were proceeding at an increasing rate. In 1938 a commission was appointed and, as a result of the report submitted, the Natural Resources Act was drawn up and became law in 1941. Under this Act, in order to prevent further destruction of natural resources in native reserves, provision is made for —

1. The reservation and demarcation against human occupation, grazing or destruction of vegetation, of certain areas.
2. The reduction of stock to a safe level on a fixed unit of land.
3. The construction of soil conservation works.
4. The obligatory maintenance of such soil conservation works by those to whose lands direct protection is afforded.
5. Penalties for damage to soil conservation works.

The construction of soil conservation works in native reserves by Government commenced in 1936, with the appointment of the first Soil Conservation Officer. Until the end of 1943, the work was confined to the protection of arable lands by means of contour ridges and storm drains, together with a limited amount of gully control. In 1944, the work was extended to non-arable areas and included contour furrows in pastures, re-alignment of roads and contour road drains, check dams, earth dams and masonry structures for gully control, and the fencing of critical areas. First priority was given to the extensive re-vegetation of drainage channels in arable areas, so as to provide for the safe discharge of water from contour ridges to be constructed at a later date when mechanical units became available. Today, we have thirty-six Land Development Officers, each of whom is, *ipso facto*, the soil conservation officer for the native areas and reserves of his district, and the annual expenditure on soil conservation works exceeds £20,000, not including the salaries of Europeans and native staff.

The compulsory reduction of native-owned stock in overstocked areas, as provided for under the Natural Resources Act, commenced in 1945, and, in the 49 reserves concerned, a nett reduction of over 73,500 head was achieved during the first year ended 31st March, 1946 (4). This was made possible by the organisation of weight

(3) Annual report of Director of Native Agriculture for 1946 : p. 44. Salisbury, S. Rhodesia. *C. S.R.* 48/1947.
(4) Report of Secretary for Native Affairs for 1946 : p. 6. Salisbury, S. Rhodesia, *C. S. R.* 48/1947.

and grade sales and the purchase of stock at fixed prices by the Cold Storage Commission and others, in place of auction sales, and the increase in meat-eating due to the encouragement given to the establishment of native-owned butcheries in reserves.

The total number of dip tanks in native areas and reserves is now 676, at which 1,636,000 cattle are dipped, or an average of over 2,400 head per dip. The Natural Resources Board have recommended that not more than 1,000 cattle should dip at any one tank and, on this basis, 1,636 tanks are required, or 960 additional tanks. Less than ten new tanks were constructed this year, owing to the shortage of cement and suitable builders. Until the average number dipped at each tank is reduced to at least 1,500, fortnightly dipping will continue to be a major cause of erosion. This will necessitate the building of at least 400 additional tanks. Should the use of gammexane, or some other substance instead of arsenic, enable ticks to be controlled by less frequent dipping than at present, this alone will reduce erosion due to the movement and concentration of cattle to a very considerable extent.

At the present rate of progress, the complete protection of over 2,000,000 acres of land by means of contour ridges may take 50 years; in the meantime, erosion is proceeding unchecked in areas where it is not yet possible to put in works owing to lack of labour, supervision or equipment. As a partial measure of conservation, which it is hoped can be carried to completion within the next five years in all but the remoter areas, the demarcation of 2-yard wide grass buffer strips on the true contour through all arable areas, at intervals of not more than 35 yards, has commenced. This will ensure that all ploughing is done on the contour and will check the movement of soil to a considerable extent. South African made Chinese water levels are to be used in pegging these strips. The local manufacture of scotch carts has so far failed to meet the native demand for wheeled transport. At present a small donkey cart costs £45. In order to satisfy this demand, a cart-making factory is being erected to train natives to make wooden cart bodies. Steel wheels and axles are being imported in bulk at low cost, and a trial lot of all-steel carts are being assembled for demonstration and sale at £25. When suitable carts are readily available, it is intended to prohibit the use of sleighs and so remove a major cause of soil erosion.

The extensive provision of additional water supplies, especially in Matabeleland and the areas of low rainfall, in the form of boreholes, dams and weirs, has done much to reduce the movement of stock and secure a more even distribution of both people and livestock. Shortage of boring machinery, equipment and trained European personnel, have been limiting factors. Labour for the construction of dams has been more readily forthcoming than for any other purpose, and in many cases the people have worked with their cattle for no payment other than a certain amount of food and salt.

For the last 8 years, an average of £20,000 per annum has been spent in native reserves in the development of water supplies (5).

In parts of some reserves, where the native population was so dense that it was impossible to provide sufficient arable lands for all the people and at the same time conserve the soil, an Order from the Governor-in-Council, as provided for under the Natural Resources Act, has been obtained to move a proportion of the population to another reserve in the same tribal area where land was available. Farms in the European area, usually bordering on native reserves, have been bought for native occupation where surplus population from native reserves has been settled under supervision. A few of these areas are models of what can be done when land use and occupation is wisely planned.

In some over-populated reserves, particularly those near the large centres of European population, there is no possibility of obtaining extra land for native occupation on a rural basis, but the Native Urban Areas Act makes provision for married quarters for native employees. Such employees may in future have to forego their right of occupation of the reserve in favour of those who are dependent for their existence on farming in the reserve and are prepared to exercise their right of occupation continuously.

Small townships are being established in reserves at points of economic vantage where native-owned trading stores, eating-houses and butcheries, etc., can provide their owners with a living and free them from the necessity of cultivating lands and owning cattle.

Soil Conservation Work Being Carried Out at Government Expense

Restriction of Areas Under Cultivation

When a native reserve is surveyed and centralised, blocks of land in which crops may be grown, varying from a few hundred to several thousand acres, are beaconed off. They include the best arable land and, as far as possible, exclude waste land, but, in many reserves, the country is so broken that inevitably both steep hillsides and vlei land are included in these arable blocks.

This centralisation is not done forcibly but in consultation with the chief, or several headmen, and the people. There is always extreme

(5) Works in Native Reserves and Areas: Annual Report of the Irrigation Dept. 1946: p. 65. Salisbury, S. Rhodesia, *C. S. R.* 48/1947.

reluctance to set aside more than a minimum of land as permanent grazing and, in consequence, many of these blocks include more arable land than the people living round them can possibly farm properly. It is only where arable land is scarce that a high standard of farming is widely practised, *e.g.*, in north-west Europe, South China, and in some of the more densely populated areas of West Africa. On the other hand, where land is plentiful and it is possible to make a living by an extensive soil exhausting farming system, as in many parts of Africa, and until recently in the wheat belts of North America and Australia, good farming in such a way as to conserve natural resources is practically unknown. Therefore, in these large arable blocks, the first essential step is to restrict the area which is available for cultivation to an acreage which the people are able to farm properly.

Each kraal head is therefore allocated a block of land sufficient for him and his followers who usually number from 10 to 20 — sometimes more — taxpayers and their dependants, and which they can use effectively. Any land which is left over is then set aside as additional grazing for the time being and for future increase in population.

The Protection and Re-vegetation of Drainage Channels and Water Courses

The first essential to all soil conservation work in arable areas is to ensure that the natural depressions and the banks of all streams and water courses into which water will drain from contour ridges are sufficiently well vegetated to take the heavy flow of storm water discharged during periods of intense rainfall. We have learnt from bitter experience that the enthusiastic construction of contour ridges through arable land, without first providing a safe discharge for the storm water so collected has resulted in worse gullies than those produced in similar land where no soil conservation work has been carried out. Even where the centre of a vlei is well vegetated, it is not safe to assume that this will remain so after contour ridges have been constructed to discharge here. In every case we have found it absolutely essential to mark very clearly the line beyond which cultivation must not extend into these drainage channels. Stone beacons erected at frequent intervals are useful as a temporary measure but are too easily picked up and thrown away to be considered as permanent. We therefore use earth banks, approximately ½-square yard in cross section, as a means of demarcating these drainage channels. In erecting these earth banks, which of course run up and down hill, earth is borrowed from pits. These are on the land side, as it is absolutely essential to disturb the soil in the drainage channel as little as possible. Where these drainage channels have been ploughed, they are demarcated at least one whole season in advance of the construction of contour ridges so as to give the natural vegetation ample opportunity to re-establish itself. We are fortunate that couch grass (*Cynodon dactylon*), various Digitaria sps., Chloridion Cameronii and other creeping grasses are common on old lands. Where there are small gullies in these natural depressions they are controlled by means of low brushwood and stake check dams, stone checks and earthen storage and diversion dams. Where the gullies are deep, a wide strip is left uncultivated on either side into which contour ridges will discharge.

These earth demarcation banks are 5 ft. wide at the base, 17″ high and 18″ wide at the top, and are soil conservation works so that any native who damages them with his oxen, by ploughing over them, can be prosecuted under the Natural Resources Act. In many reserves almost all the available labour has been employed during the past two years on this type of work, and the growth of grass in these drainage channels is astonishing ; and the mere fact that these have been thrown out of cultivation has done a great deal to hold up water and reduce the amount of silt finding its way into the streams and rivers.

In laying out soil conservation work in arable areas, frequent roads of access to lands have to be provided so that natives have no excuse for making paths across contour ridges (6). Roads of access therefore alternate with drainage channels, the roads running, wherever possible, down the minor water-sheds. To minimise the possibility of paths being formed, these roads of access have to be frequent, and the lengths of the contour ridges, which in every case run from the road of access to the drainage channel, have to be kept less than 300 yards. The usual length is from 200 to 250 yards. The maximum distance between one drainage channel and the next is therefore 600 yards, but in practice rarely more than 500 yards. In certain types of country, the natural depressions are not sufficiently frequent, and we are therefore compelled to create artificial drainage channels at intervals between the natural drainage channels. Low places are chosen wherever possible and great care has to be taken to see that, in demarcating these, there is no appreciable difference in level from side to side, otherwise storm water discharged into them would tend to break out and run back through the lands.

These grassed drainage channels are our biggest problem. Even where roads of access are only 500 yards apart, it is very hard for natives to realise that the drainage channels must not be used as paths and sleigh tracks, and the outlets of the contour ridges as a means

(6) Aylen, D. *Rhodesia Agricultural Journal* (1942) xxix, 3, 152.

of access to their lands. It is difficult to catch offenders in the act of using the drainage channels in this way and so secure conviction. Thorn and brushwood fences at the top of drainage channels are being used and, as soon as wire is available, fences will have to be thrown across them to prevent passage up and down. Complete enclosure, except as a temporary measure, is undesirable, as if the grass is allowed to grow unchecked fire will break out sooner or later and result in a complete burn and the exposure of bare soil which would erode easily.

Where the land is steep and up and down hill ploughing has been extensive and prolonged, and there are numerous gullies, it is almost impossible to find anywhere to spill water safely and let it flow down a long slope unimpeded. The wise way to use such land would be to throw it out of cultivation and construct small dams across all gullies at frequent intervals. Unfortunately, in many reserves, such lands are required for cultivation as no other land is available for the people. Various expedients have to be adopted and we are still experimenting. Contour ridges have been successfully constructed to lead water away from depressions, where these are seriously gullied, and spill it down a rocky ridge or outcrop. Any small section of unploughed grass land may be used to drop water down a short distance into a small dam and away in a large graded storm drain to where it can be safely discharged. Fairly large dams — designed to catch silt and hold water and stop erosion by allowing storm water moving down the drainage channel to expend its force by falling into a body of water — have been built across gullies. The spillway is so selected as to be on the same level as the head of the gully and further eating back is therefore checked. Large volumes of water held up in this way have enabled vegetation to re-establish itself very rapidly. By providing additional drinking places, these dams reduce the movement of cattle to and from the river banks and permanent watering places for at least the early part of the winter. The position of such dams is often conditioned by the presence of a suitable rock bar or well-grassed vlei up to half-a-mile up stream on to which the overflow can be discharged along a large storm drain.

The destruction of vegetation within 200 feet of public streams in native reserves was prohibited by Government Notice No. 42 of 1938 and is an offence punishable by imprisonment. The majority of natives are ignorant of this regulation, and the banks of large numbers of streams have been ploughed up. To indicate the margin not to be cultivated, earth banks ten yards long are erected at intervals along a line approximately 200 ft. from all streams running through arable areas. In some areas the rigid adherence to 200 ft. would deprive the people of a large proportion of their available arable land and, in such cases — especially where the stream is small — the line of earth banks is made at such a distance from the stream as to exclude only steeply sloping land and keep cultivation safely above the highest flood level. By definition, a public stream is a channel through which water normally flows for a portion of the year. The distinction between streams and gullies is therefore not absolute, but all large gullies that cannot be crossed by contour ridges are treated as streams.

The Protection of Arable Land

For our erodible soils and high rainfall intensities, both vertical and horizontal distances between one contour ridge and the next must be small. In order to economise labour and protect greater acreages, many of the earlier ridges were constructed at vertical intervals of 6 ft. and more, and up to 70 yards apart. Wash and considerable erosion occurred in the lower half of many contoured lands, and the deposits of sand in the contour channels caused water to be held up and break over the tops of the ridges. Many serious gullies were formed in this way. Two similar blocks of typical, steep, badly eroded granite sand in the Victoria reserve were carefully contour ridged. In one, the ridges were at 4 ft. vertical intervals and in the other at 3 ft. vertical intervals. In each block, the slope varied from 1 in 10 to 1 in 30. Both blocks were fully ploughed on the contour by the natives and planted to crops. A certain amount of soil movement occurred in the lands between ridges at 4 ft. vertical intervals, but practically none where the vertical interval was 3 ft. In neither case was any considerable quantity of sand or silt deposited in the contour channels. From this experiment it was concluded that on typical granite sand veldt, 4 ft. is a safe vertical interval between contour ridges.

Surveys of earlier work indicated that a large proportion of the drainage channels had developed gullies, and it was evident that in many cases water was being discharged at scouring velocities from the ends of contour channels. The standard gradient used was 1 in 400. For this reason a gradient of 1 in 600 was used in the test blocks referred to above. Although the drainage channels were very steep, no scouring occurred, nor was there any silt deposited in the contour channels.

Native demonstrators do all pegging, and we have therefore been compelled to dispense with variable gradients and formulae for distances between contour ridges according to slope, and until additional professional staff makes further investigation possible, a fixed grade of 1 in 600 or 1″ in 17 yards and ridges at 4 ft. vertical intervals or a maximum distance of 40 yards apart has been adopted as standard practice. 50 yards is permissible when an ant hill has to be avoided. Results have so far been very satisfactory. Contour channels are fanned out and turned down hill a few inches where

they discharge. To prevent silting up, this has to be more pronounced on gentle than on steep slopes. A storm drain protects the uppermost land from wash, and the lowest contour ridge marks the limit of cultivation. It is impossible either to estimate the run off above every storm drain or for native demonstrators to vary grades and capacities frequently. Two experimental storm drains dug in granite sand on gradients of 1 in 200 and 1 in 132 respectively, both eroded, one to a depth of 30″, so storm drains are now dug on a gradient of 1 in 400, and 6 ft. or 12 ft. wide, according to the expected run off. Only in wet or heavy soils where there is no danger of erosion is a gradient of 1 in 200 used. We have found that such drains have to be cleaned out only where there is heavy trampling.

In constructing ridges by hand, a wooden form is used, ¾-sq. yard in cross section, 7 ft. wide at the base, 18″ high and 2 ft. wide at the top. The earth is taken from a channel 2 to 3 yards wide, according to the slope, being of necessity narrower and deeper on steep slopes than on gentle slopes. A berm 1 ft. wide is left to prevent earth falling back into the channel. Any grass growing on the berm spreads easily up the bank. The line of the channel is ploughed first to lighten the work, and when this is done a daily task of up to 24 yards per boy is possible.

Ditchers of various types, drawn by oxen, are being increasingly used to replace hand labour, and but for the shortage of mechanical equipment the use of hand labour in the construction of contour ridges would have been largely dispensed with by now.

Where gullies through lands have to be crossed by contour ridges, it is most important to complete the gully crossings *before* the ridges are constructed, not after, as in the latter event there is always the possibility that untimely rain will result in ridges discharging water into gullies not yet crossed.

The sides of the gully are cut back to a 1 in 1 slope, and the bottom is cleaned out. Earth is then taken from the shoulders of the gully above the pegged line, and the bank is built up at least a foot higher than the normal height to give extra strength and allow for sinking. When picks and shovels are used, the earth is well rammed and tramped. All construction work is under the direct supervision of a native overseer, and he needs frequent checking to ensure proper consolidation and to prevent the inclusion of logs and boulders in the walls of these gully crossings, with disastrous results. Where the gully is deep and the earth very sandy, ant-heap or vlei soil, well tramped, should be used as a core. Where the ground is not too hard, oxen and dam scoops can be used to great advantage. When the ridges are built by means of ditchers or graders, the oxen or tractor goes over the previously made gully crossings and helps to consolidate them. The gully above the bank is not filled in. This acts as a dam and silt trap and gradually fills up in the course of ploughing and cultivation. The banks of large gullies are left uncultivated until the sides have fallen in and natural re-vegetation has raised the bed sufficiently to permit ploughing across. Gullies in lands are so numerous that to use labour or machinery to level them is out of the question.

For the first season no ploughing is allowed in the contour channel, to make quite sure that the plough does not come anywhere near the bank. Later, ploughing is extended gradually into the channel, always throwing the furrow slice uphill so as to keep the channel open and counteract the tendency of the soil to move downwards and cause terracing.

According to native law and custom, land is vested in the chiefs and headmen and held by them in trust for their people. Land in a native reserve cannot be owned individually, but is allocated to individuals by the chiefs and headmen for as long as they require it and actually use it. Each individual normally holds several scattered lands. As soon as a headman's area has been fully protected, a meeting of the people is called and the land is re-allocated by the agricultural demonstrator and the headman, so that each taxpayer has a contiguous block of land bounded by a road of access and a drainage channel and consisting of a number of strips between contour ridges. Where sufficient land is available, 6 acres are allocated to each man and his wife plus 2 acres for each additional wife or adult dependant. Headmen and chiefs are given extra land, and in lower rainfall areas or stony ground larger allocations are made. Under the Natural Resources Act, the obligation to maintain and repair soil conservation works lies with the individual to whose lands these works afford direct protection. Hitherto, the agricultural and soil conservation demonstrators have been employed to instruct and advise individuals how to maintain ridges, but they are not sufficiently numerous and have other duties besides, and so far the maintenance of ridges has been most unsatisfactory. In an attempt to overcome this, a start has been made in the employment of maintenance boys, each of whom will have a definite area to patrol. His duties will be solely to inspect all works and advise and instruct the individuals concerned how to maintain and repair them and how to plough their lands so as to keep the contour channels open. Individuals who fail to carry out his instructions will be reported by him to the chief or headman and the Land Development Officer, and as a last resort, his evidence can be used to secure prosecution and conviction of offenders.

Strip cropping is encouraged by the practice of crop rotation, the contour ridges forming the boundaries between the different courses. A few progressive chiefs and native councils are

insisting on a systematic crop rotation and manuring on all land that has been contour ridged, but much remains to be done in this respect.

Road Drainage and Soil Conservation

Motor roads in reserves are, wherever possible, re-aligned so as to follow the watersheds. This facilitates drainage and reduces to a minimum the number of drainage channels and water courses that have to be crossed. The road surface is cambered and flood water led off in contour drains at 4 ft. vertical intervals or a maximum distance of 100 yards apart and alternating on both sides of the road. These drains are given a fall of up to 6″ in the first 10 yards and are then dug on the same gradient as the contour ridges but up to a maximum of 1 in 200 in wet land, so that storm water is carried well away and spilled into the velt or carried right through arable lands by contour ridges to a water course or drainage channel. Gullies caused by old roads are crossed and the water held up in them materially assists in re-vegetation. Masonry drop inlets, properly designed culverts, stone and cement weirs, etc., are essential for soil conservation and safe water disposal, and are being constructed in increasing numbers. Very satisfactory box culverts up to 30″ x 30″ have been made with the minimum of cement, using 3 to 4 ft. long granite slabs easily obtained from the flat granite outcrops (ruwaris) so common in many parts of the country.

Soil Conservation Works in Non-Arable Areas

Soil conservation works are undertaken in the grazing areas to control gullies, hold up water and assist in re-vegetating overstocked and tramped-out areas, particularly around dip tanks. The aim in all cases is to hold up water and delay its concentration into any one channel for as long as possible. Short, low, dead level banks and troughs, with the spill-ways staggered; level, interrupted furrows ploughed at intervals of 4 or 5 yards through heavily-grazed pastures, and solid earth dams across gullies designed to fill these with water, catch silt and assist in vegetation, have proved most successful. Small, low stake and brushwood check dams and rough stone check dams have also been successful, but only where measures have been taken higher up in the catchment to reduce run-off. The smoothing down of the sides of gullies has not proved effective in these sandy soils, and has almost invariably resulted in all the earth moved being carried away, and the gully correspondingly widened. It is in any case very expensive. If the head of the gully is cut off by means of a storm drain and the run-off held up by protection above and by dams or weirs below, re-vegetation of the floor is rapid and the vertical sides tend to fall in by degrees so that the floor is raised and the sides become less steep. Moderate grazing and tramping by cattle assist.

Very large sums of money can be spent on earth and masonry structures in or on the banks of major gullies in an endeavour to control or heal them, but unless the cause of erosion in the form of land abuse within the catchment is sought out and remedied, these structures may need constant repair and maintenance. Often the complete protection of part of the catchment, to allow re-vegetation, is the only solution. A wire fence, some of it only temporary, has often proved far more effective and much cheaper than extensive diversion drains and other earth works. On the other hand, complete and continuous protection is dangerous unless fire can be effectively excluded, and this in a native reserve is almost impossible.

Couch grass (*Cynodon dactylon*) is a normal stage in the plant succession in all but the very low rainfall areas, and has been planted with great success in denuded areas. So far, nothing has been found to equal it.

The white poplar does very well in gullies where there is sufficient moisture, and kikuyu forms an excellent cover on rich black soils where there is a high water table or at high altitudes.

Two strains of East African star-grass are quite promising in the higher rainfall areas, and cover the ground and root down more vigorously than the indigenous couch grass.

Kudzu vine has been tried out extensively, but is nowhere a success on the granite sands.

Much of the grazing land in native reserves is wooded and has only a poor ground cover of grass and herbs. Heavy grazing of such land results in a rapid destruction of the grass and heavy run-off and soil erosion.

Old lands, abandoned as a result of centralisation and which were grass lands a few years ago, are gradually reverting to the natural vegetation climax, a Brachystegia-Isoberlinia dominant formation on the granite sands, and various Acacia sps. on the heavier soils and in the lower rainfall areas. Heavy grazing assists the ecological change by preventing the possibility of the fierce grass fires which would otherwise check the growth of young trees. Fortunately, this does not apply in the vleis, which are the most valuable grazings, but it results in a reduced carrying capacity and increased erosion in all well-drained soils.

Experimental clearing of such heavily-bushed areas has resulted in an immediate increase in carrying capacity, and the planting of couch and other grasses has been most successful. But, even after thorough stumping, the bush comes in again after a very few years. A chemical poison of the growth-promoting-hormone type which could be applied to the stumps, or sprayed on to re-growth, might solve the problem. Regular mowing of level areas

and controlled burning of broken areas after stumping and clearing is a possible future solution. In the meantime, mechanical equipment in the form of bulldozers or pneumatically operated cutters are required to clear this bush.

The old system of shifting cultivation, with periods of fallow alternating with periods of cultivation, did much to keep the ecological succession from reaching its climax, in which trees are dominant, and to encourage grasses. When wire is obtainable and it is possible to divide the grazing areas into paddocks, the obvious solution will be to bring each paddock under cultivation in turn for a short period of years, ensure thorough stumping, and then allow it to revert to grazing, under-sowing or under-planting the last crop in the rotation with a suitable grass. Unfortunately, the chiefs or headmen have not sufficient authority or control over their people to make this possible without the use of wire. With closer European supervision and better administrative control, wire might be dispensed with and the grazing of cattle controlled instead by cattle guards, areas to be rested from grazing being marked by beacons.

In all reserves there are areas where even moderate grazing results in heavy run-off and erosion due to the very poor grass cover under trees and bush on very steep slopes, very poor stony soil or among rocks. Such areas should be set aside as indigenous timber reserves in which controlled felling of timber could be organised, but where grazing should be prohibited. Under existing legislation, grazing would have to be prohibited in such timber reserves by the Minister of Agriculture and Lands in terms of the Forest & Herbage Peservation Act (Chapter 176), Section 11 (I) (b).

Such timber reserves should not be confused with specified areas in which the taking of forest produce may be prohibited by the Minister of Native Affairs under the Native Reserves Forest Produce Act (Chapter 93), Section 15 (2). Sacred groves dedicated to ancestral spirits which are of scientific value or interest are being surveyed, demarcated and gazetted in some reserves as specified areas of indigenous forest.

Summary and Conclusions

The extent of soil erosion in native reserves, its chief causes, and the steps being taken to conserve the soil, have been described. Advanced soil erosion was already widespread before the urgent need for soils conservation was appreciated. Inevitably, attention was focussed first on the need for curative operations such as earth contour banks and storm drains, smoothing out gullies, check dams, stone drops and masonry works, all designed originally to control and dispose of water and silt already on the move. On the other hand, insufficient attention was paid both to the reduction of run-off and soil movement wherever rain falls and also to the ultimate disposal of storm water on to uncultivated land in depressions and into water courses.

Prevention, as with most diseases, is better and cheaper than cure, and properly planned land utilisation is the first essential in the prevention and control of soil erosion. Gross abuse of land cannot be rectified by earthworks and masonry, no matter how extensive, and the following are the main points to be taken into consideration when planning land use in native reserves.

1. All lands to be ploughed and cultivated and row-crops planted on the contour.
2. Excessively steep slopes (a 10% slope is tentatively suggested as the absolute limit for cultivation), the banks of rivers and streams, water disposal channels and the centres of vleis, to be left uncultivated and moderately grazed.
3. Contour grass buffer strips at frequent intervals through all lands.
4. The maintenance of humus content of arable lands by application of sufficient organic manure and by crop rotation.
5. The situation of kraals on gently sloping land, and not on steep ground, or near water courses where trampling will cause rapid run-off difficult to control.
6. Limitation of population and livestock and their even distribution.
7. The reduction of movement and concentration of cattle to a minimum by the provision of adequate and well-distributed dip tanks and watering places.
8. The control of grazing.
9. Proper road alignment, construction and drainage.
10. The prohibition of wooden sleighs and their replacement by wheeled transport (preferably pneumatic-tyred).
11. The improvement of grazing by the eradication and control of bush and trees.
12. The setting aside of steep, wooded areas as indigenous timber reserves and the prevention of grazing therein.

Protective measures are nevertheless required to mitigate the effects due to past misuse of land and to enable land to be used more intensively than would otherwise be possible. These are mainly :—

1. The control of gullies in and re-vegetation of natural drainage channels.
2. The construction of contour ridges and channels through sloping arable lands.
3. Pasture furrows, channels and banks in heavily-grazed areas.
4. Earth dams and diversion drains across gullies and over heavily-tramped ground round dip tanks, across old roads, cattle tracks, etc.

5. Dams and weirs to hold water in drainage channels that have gullied and in water courses, to raise the water table and assist in re-vegetation.
6. The erection of fences to give complete protection to badly eroded areas.
7. The re-vegetation of denuded areas.

In 1946, the cost of protecting arable land with contour ridges and storm drains by hand labour, including rations but not wear and tear of tools or supervision, averaged approximately 11/- per acre. Two million acres is a rough estimate of the arable land that remains to be done which, on this basis, will cost £1,100,000. This does not include protective work required in non-arable areas or allow for purchase of tools and equipment, which will raise the cost to £2,000,000 at the most conservative estimate. A trial block of 640 acres protected this year by power-driven equipment indicates that the cost is higher by this means than by hand labour at present rates of pay.

The cost of roads, water supplies, dip tanks and fencing for paddocking grazing areas, protecting water supplies, drainage channels, critical areas and timber reserves — all of which are essential to planned land use and conservation — is impossible to estimate, but it will run into millions of pounds.

For the year 1946, protection work in 37,000 acres of drainage channels, arable and non-arable land, cost over 270,000 working days with pick and shovel, leading and driving oxen, etc. This was all paid labour and most unwilling. With the increasing demands for labour by industry, mining and farming, it is doubtful if even this small amount of paid labour can be employed in future. Large tractors in reserves where lands are large, and small tractors in reserves where the country is broken and lands small and scattered, will have to be used.

Soil conservation works have been carried out by paid labour as a charge against Government loans, in 45 different reserves, and in the majority of reserves, where agriculture as opposed to cattle-ranching is carried out extensively, some arable lands have been protected, and at least a few of the natives are convinced of the value of conservation works. But, human nature being as it is, the attitude of the majority is " the Government came and put in these contour ridges and the Government can come and repair them " and, consequently, in spite of legal sanctions, repair and maintenance of soil conservation works is most unsatisfactory and is already a major problem in some reserves.

In a few reserves, keen administrative and technical officers have persuaded groups of natives to protect their own lands, some using picks and shovels and others ditchers supplied by the Government, but using their own oxen and ploughs. In some cases, payment has been made according to yardage constructed, in others the work has been done for nothing.

The difficulty with voluntary work is to get the full co-operation of everyone, so that all ridges in a catchment are completed, half-finished works being likely to cause more serious erosion than no work at all. Powers are needed to compel unwilling members of a community to take their share of work, or pay for the cost of having it done. Native Councils, where established, have power to tax their members and, among other things, to carry out soil conservation works. The attitude of many natives, especially those who are partially educated, is that the Government should do more and more for them, and it is questionable whether individuals can develop a sense of responsibility until they are compelled to co-operate and do things for themselves. Yet, in carrying out a plan of land use, the first essential is to obtain the full support of the people. A considerable measure of co-operation has been obtained in improved agricultural practices and living conditions through the medium of demonstrators, but more is required. Where chiefs and headmen will not, or cannot do so, the Native Council is perhaps the only way in which we can hope to obtain the necessary co-operation of the people as social units rather than isolated individuals. I look forward to the day when Native Councils will raise funds to run small tractors, employ labour, buy wire and construct all soil conservation works in their areas, receiving assistance and subsidies from Government in the same way as Intensive Conservation Committees in the European area.

Acknowledgment

The demonstration of improved methods by trained natives to the inhabitants of native reserves was inaugurated by the present Director, E. D. Alvord, M.Sc., twenty years ago, and I wish to thank him for allowing me to publish this account. I can claim to have done no more than carry the work started by him a few steps forward. The progress made would not have been possible but for the energy and enthusiasm of the European and native staff of the Department of Native Agriculture, the wholehearted co-operation of administrative officials in many districts, and technical assistance rendered by individuals of many other departments.

Salisbury, Southern Rhodesia,
August, 1947.

YIELDS IN CACAO EXPERIMENTS 1945–46

BY

E. E. CHEESMAN

Yields from the field experiments of the Cacao Research Scheme in the crop year September 1945 — August 1946 are presented in Table I in a form similar to that adopted in two previous reports. * The table shows yields for the current year, yields for the four previous years, and aggregate yields since planting. Yields of CRB 1 in 1940–41 have been omitted in order to keep the table compact. The figure for "lbs. dry cacao per acre" is calculated in each case from the weight of wet cacao from 96 trees, taking the loss of weight in preparation as 60 per cent.

An interesting feature is the very different behaviour of the four plantings of different ages. In total yield CRB 1 is down to 84% of last year's figure and CRB 2 down to 63%; CRB 3 is up to 119%, and CRB 4 up to 172%. One particularly curious result is that the yields of the four plantings are in order exactly inverse to their age, the 5-year trees of CRB 4 giving more cacao than the 8-year trees of CRB 1. Viewed by themselves and superficially, these figures might give the impression that the older plantings have already passed their maximum and are on the decline; but closer examination discloses no reason to suppose that the reduced yield is anything more than a temporary effect, though a sufficiently important one to merit some discussion.

The real interest of the figures lies in their illustration of the many factors combining to

* (1) Cheesman, E. E., Results of Cacao Experiments in 1944-45. *Trop. Agriculture, Trin. 23*, 63-65.
(2) Cheesman, E. E., Field Experiments in Cacao Research 1943-44. *Trop. Agriculture, Trin. 22*, 64-66.

TABLE I

Yields calculated as "lb. dry cacao per acre." Pod values as "pods to 1 lb. dry cacao."

Experiment and year of planting	Clone	Yield 1941-42	Yield 1942-43	Yield 1943-44	Yield 1944-45	Yield 1945-46	Aggregate yield since planting	Pod value 1945-46
CRB 1 1937	ICS							
	1	148	645	739	895	471	2986	7.5
	3	14	36	113	210	149	543	7.7
	4	54	75	260	297	288	1033	8.4
	5	10	34	85	234	186	568	6.7
	6	91	470	686	635	883	2850	5.8
	8	170	433	796	806	608	2928	7.0
	Average	81	282	448	510	431		
CRB 2 1938	ICS							
	1	75	591	326	937	677	2606	7.1
	7	6	38	119	349	302	814	7.3
	16	174	413	325	921	614	2447	7.4
	22	42	301	161	404	311	1219	8.6
	45	177	548	306	855	413	2299	8.2
	53	56	294	214	721	330	1615	9.7
	Average	89	367	242	698	441		
CRB 3 1939	ICS							
	1	—	357	518	559	695	2129	7.4
	2	—	152	162	272	341	927	7.5
	9	—	100	172	213	289	774	8.5
	12	—	194	173	213	233	813	8.0
	60	—	347	658	653	773	2431	6.5
	98	—	249	515	460	585	1809	11.6
	Average		231	369	395	470		
CRB 4 1940	ICS							
	1	—	—	311	532	885	1728	7.8
	44	—	—	124	356	562	1042	9.4
	55	—	—	80	253	387	720	11.2
	70	—	—	97	277	461	835	9.8
	91	—	—	93	237	531	861	9.3
	95	—	—	279	526	914	1719	11.8
	Average			164	363	623		

influence the yield of any clone in a given year. In these experiments, where soil variation within plantings is largely neutralized by the lay-out, the chief factors are age, season, and past performance. Of those factors, past performance is the one which most complicates yield studies in all tree crops, and notoriously makes their behaviour more difficult to interpret than those of annuals. In the present year's results it seems to have played a major part in causing the inconsistencies noted.

It is a rule with many fruit trees that heavy bearing in one year tends to be followed by a light crop in the next, and not infrequently a more or less regular alternation of "high" and "low" years is set up, which is often called "biennial bearing". The question whether true biennial bearing occurs in cacao, and the significance of regular fluctuations in yield, are among the problems which we hope to be able to study when records have accumulated for several more years. For the present it is sufficient to note that a more or less regular alternation of high and low yields has long been recognized in mature seedling cacao fields.

In Table I, the behaviour of CRB 2 is strongly suggestive of biennial bearing, but the very striking ups and downs of this planting may be partly fortuitous, and it would be unsafe to lay emphasis on them while the number of crops taken is still so small. On the other hand, it seems entirely legitimate to use these figures as illustrations of the importance of past performance in more general terms. There can be little reasonable doubt that the low yield of CRB 2 in 1943-44 was both a result of the high yield of 1942-43 and a contributory cause of the high yield of 1944-45. In each year, of course, age and season had their effects, but the general run of the figures suggests that all three seasons were fairly good ones. There is certainly nothing in the figures from other plantings to suggest that 1943-44 was a particularly unfavourable season. Therefore the only plausible interpretation of the big drop in yield is that it was mainly due to the physiological condition of the trees after an exhausting crop the year before. In 1944-45 it would appear that a good season, the increased age of the trees, and their condition after a rather light crop, all worked together to produce the record-breaking yield of that year. That yield has had an after-effect this year, and, in conjunction with what seems to have been on the whole a relatively unfavourable season, has swamped the age factor for the second time in the history of the experiment.

Applying a similar interpretation to the behaviour of CRB 3, we find it quite consistent. In 1942-43, CRB 3 was only three years old, with no previous bearing history: it reacted to the favourable season to give a good yield for its age, but not an exhausting one. In 1943-44 the substantial increments in all clones (except 12) are mainly due to the increased age, and the yield is almost identical with that of CRB 2 in the previous year. Just as in the case of CRB 2 there was an exhaustion effect in the following year, when ICS 1 increased very little and ICS 60 and 98 both dropped, in spite of being a year older. That the effect was less marked than in CRB 2 may well be ascribed to the different season: in this case season and age were working together against after-effects of a heavy crop, and the two sets of factors almost cancelled each other out. In 1945-46, age and season have worked against each other, with the effect of last year's performance problematical, and the result has been an all-round increase, but not as big as that in CRB 2 last year.

The interpretation of CRB 1 is rather more complicated, but not inconsistent. This planting had to contend, both in 1940-41 and in 1941-42, with unusually severe dry seasons, and was further handicapped by inadequate shading. Consequently it was five years old when it experienced its first favourable season (1942-43) and in that year it gave yields of the same order as the four-year-old CRB 2 adjacent to it. The extra age and size of the trees is sufficient to explain why there was no exhaustion effect in 1943-44; on the contrary, age and season working together forced a very high crop on the better three clones (1, 6 and 8), and in two of them (6 and 8), there was a definite exhaustion effect in 1944-45, which it is interesting to compare with that in ICS 60 and 98 in the same year. ICS 6 showed the greater effect in 1944-45, and was the only clone in CRB 1 to show an actual reduction; this year it is the only one to show an increase. ICS 8, which remained almost stationary in 1944-45 (age and season working together against past performance) has gone down this year much less than ICS 1, which showed a substantial increase last year. Thus ICS 6 and ICS 8 have got "out of step" with each other, but both show effects of past performance.

The behaviour of ICS 1 in this set looks anomalous, but on closer examination provides a pretty confirmation of the general hypothesis. ICS 1 is more irregular in age than the other clones in CRB 1 and only 47 of its 96 trees are originals planted in 1937: 37 were planted in 1938, and 12 are supplies of later date. When the yields of the 47 trees of 1937 are separated from those of the 37 trees of 1938, and the few younger ones are left out, we get the interesting analysis shown in Table II, where the total bearing is given as average number of pods per tree.

TABLE II

Average number of pods per tree in ICS 1

Crop Year	1942-43	1943-44	1944-45	1945-46
47 trees planted 1937	23.2	26.6	24.9	15.2
37 trees planted 1938	18.1	18.0	29.3	11.7

Evidently the five-year trees were (as postulated above) less affected by the heavy crop of 1942-43 than the younger ones, but after two good yields in succession they show an exhaustion effect in 1944-45 and thus fall into line with ICS 6 and 8. However, 25 pods per tree is still a heavy crop, and the major effect of previous heavy bearing was deferred until this year, just as it was also with ICS 8. The trees planted in 1938 are directly comparable with CRB 2 and show similar behaviour, a marked check in 1943-44, followed by a heavy increase in 1944-45 and a heavy slump in 1945-46. The complex interactions of season, age and history apparent here serve to illustrate once more the extreme caution that must be exercised in drawing any conclusions from these still young plantings.

CRB 4, with its big increments in all clones, seems to contradict the assumption based on the three older plantings that 1945-46 was a relatively unfavourable season. This may be ascribed to interaction of season with age, which may operate through the circumstance that the five-year trees of this planting are not yet competing with each other to anything like the extent of the seven and eight-year trees, nor are they yet forming a canopy, so that conditions in the field are quite different. Furthermore, CRB 4, though nominally planted in 1940, had to be rather heavily supplied in its earlier years and only 422 of its 576 trees are originals, there being 69 four-year, 55 three-year and 30 two-year trees in the set. Some of the increment this year was therefore due to trees coming into bearing for the first time. The performance, even without allowing for any age handicap, is astonishingly good, and there will be some cause for surprise if no effect is traceable in next year's yield, though it may be masked by the coming into bearing of the rest of the younger trees.

Two experiments not included in Table I are CRB 5 and CRB 6. CRB 5 is a test of six Criollo clones, planted in 1940-41. It gave a lot of trouble in establishment and is consequently now heterogeneous in age. The yield this year (at a nominal 5 years old) was only 187 lb. per acre, and for the present the results are not worth further discussion. The standard clone in this set is 45, which gave 329 lb. per acre, and none of the others so far show any signs of being better than it. The planting is useful for various observations on Criollo cacaos but not suitable for statistical analysis.

TABLE III

Yields of CRB 6, 1945-46

(Trees 3-4 yrs. old)

Clone	Kilos (wet) from 48 trees	Lb. (dry) per acre (Calculated)	Pod Value
ICS 1	60.21	334	7.9
25	39.77	221	8.3
31	46.11	256	9.2
32	62.40	346	8.7
36	27.70	154	9.0
67	11.91	66	9.6

TABLE IV

Aggregate yields of wet cacao in kilos

Experiment CRB 1 **CROP YEARS 1942-46** **Age of fields 5-9 years**

	I.C.S. 1		I.C.S. 3		I.C.S. 4		I.C.S. 5		I.C.S. 6		I.C.S. 8		Totals for buddings	Totals for cuttings	Totals for blocks
	B	C	B	C	B	C	B	C	B	C	B	C			
Block 1 Chupon	91.7	121.1	8.9	9.1	31.8	43.1	12.4	20.7	78.2	98.1	76.9	108.2	299.9	400.3	700.2
Block 2 Fan	110.1	129.5	13.3	17.6	23.1	33.3	21.3	16.4	75.6	103.4	84.3	142.3	327.7	442.5	770.2
Block 3 Fan	56.2	88.3	20.9	24.7	27.5	44.4	8.5	23.9	84.9	106.6	78.2	122.7	276.2	410.6	686.8
Block 4 Chupon	65.0	66.6	13.8	25.9	16.3	23.9	15.4	21.7	28.0	92.2	30.3	62.0	168.8	292.3	461.1
Block 5 Chupon	53.8	69.8	11.8	15.0	19.4	33.2	10.9	23.4	53.0	62.6	49.5	55.8	198.4	259.8	458.2
Block 6 Fan	61.4	77.9	11.1	11.7	14.0	22.2	11.6	8.7	73.5	107.8	48.9	94.4	220.5	322.7	543.2
Totals	438.2	553.2	79.8	104.0	132.1	200.1	80.1	114.8	393.2	570.7	368.1	585.4	1491.5	2128.2	3619.7
	991.4		183.8		332.2		194.9		963.9		953.5				

B—Buddings, C—Cuttings

TABLE V

Pod Values in CRB 1, 1942-46

(The average weight of wet cacao per pod is given in each case in grammes, followed by the calculated number of pods required to make 1 lb. of dry cacao).

ICS	1	3	4	5	6	8
1942-43	148	138	147	168	194	158
	7.7	8.2	7.7	6.7	5.8	7.2
1943-44	152	151	142	181	185	155
	7.5	7.5	8.0	6.2	6.1	7.3
1944-45	152	145	138	170	194	145
	7.5	7.8	8.2	6.7	5.8	7.8
1945-46	152	147	135	169	194	161
	7.5	7.7	8.4	6.7	5.8	7.0

CRB 6 is a set of six self-compatible clones and was planned and partly planted in 1941. It was to contain both chupon and fan material, but on account of accidents in the chupon nurseries it was not completed until 1944, and the comparison of the two kinds of material will probably never be valid. The three fan blocks were completed between August 1941 and September 1942, and are not more irregular than some of the earlier experiments. These, therefore, have been recorded this year as three-to-four-year trees, and comparison between the clones will be fairly accurate as the trees age, though based on 48 trees of each clone instead of the usual 96. The yields in 1945-46 are given in Table III.

The yield of ICS 1 is comparable with its yield at a similar age in earlier experiments. The age bias is in favour of ICS 25, 32 and 36, which consist of four-year-old trees only. No conclusions are to be drawn from these figures.

Table VI

Distribution of crop by time of year

Planting	Age	Year	% crop harvested		
			Sep.-Dec.	Jan.-Apr.	May-Aug
CRB 1	5	1942-43	1	17	82
	6	1943-44	9	18	73
	7	1944-45	8	36	55
	8	1945-46	20	42	37
CRB 2	4	1942-43	2	12	87
	5	1943-44	16	46	37
	6	1944-45	16	25	59
	7	1945-46	22	37	41
CRB 3	3	1942-43	-	12	87
	4	1943-44	12	32	56
	5	1944-45	9	18	73
	6	1945-46	30	39	31
CRB 4	3	1943-44	13	19	68
	4	1944-45	10	24	65
	5	1945-46	18	50	32
CRB 6	3-4	1945-46	9	59	32

Table VII

Percentage loss of pods by Witches' Broom disease

	Total 1942-43	Total 1943-44	Total 1944-45	Total 1945-46	Feb. 1944	April 1944	May 1944	Jan. 1945	Feb. 1945	March 1945	Nov. 1945	Dec. 1945	Jan. 1946	Feb. 1946	March 1946
ICS 1	9	10	13	7	62	18	10	25	46	24	13	27	4	4	14
ICS 6	5	7	9	12	68	23	7	23	35	17	17	37	13	3	11
ICS 8	18	14	29	18	92	30	11	77	86	42	28	57	42	12	40

Table VIII

Average yields in pods per tree (1942-46) of trees planted in 1937

Type of tree	Number of trees	Average No. pods per tree
ICS 1 buddings	28	84.5
ICS 1 cuttings	19	97.7
ICS 3 buddings	23	16.5
ICS 3 cuttings	47	22.9
ICS 4 buddings	23	29.1
ICS 4 cuttings	44	39.1
ICS 5 buddings	22	16.4
ICS 5 cuttings	18	27.0
ICS 6 buddings	27	56.2
ICS 6 cuttings	36	70.2
ICS 8 buddings	24	68.0
ICS 8 cuttings	39	116.0

Table IX

Percentage of total clonal yields given by buddings

	1942-43	1943-44	1944-45	1945-46	Aggr.
ICS 1	47	44	44	41	44
3	43	34	51	40	43
4	29	38	39	45	40
5	35	41	44	39	41
6	39	46	43	36	41
8	35	37	38	44	39

Table X

Average pod values (gm.)

ICS	1942-43		1943-44		1944-45		1945-46	
	B	C	B	C	B	C	B	C
1	142	156	144	157	150	152	148	154
6	185	200	181	189	194	194	190	196
8	156	160	153	156	146	144	163	160

Table XI

Coefficients of variation

Population	No. trees	Single crops				2-year aggregates			3-year aggr.	4-year aggr.
		42-43	43-44	44-45	45-46	42-44	43-45	44-46	42-45	42-46
ICS 1 buddings of 1937	*28*	54	39	57	72	39	37	55	40	41
ICS 1 cuttings of 1937	*19*	74	52	60	86	52	50	64	44	52
ICS 1 buddings of 1938	*13*	78	56	57	57	42	43	44	44	38
ICS 1 cuttings of 1938	*24*	50	71	51	60	49	44	43	39	38
ICS 6 buddings of 1937	*27*	82	76	63	71	58	44	45	38	39
ICS 6 cuttings of 1937	*36*	76	66	64	47	50	48	41	41	39
ICS 8 buddings of 1937	*24*	81	79	66	51	72	62	48	62	52
ICS 8 cuttings of 1937	*39*	59	51	60	63	46	42	43	41	40

PHOSPHATE FIXATION IN BRITISH GUIANA SUGAR-CANE SOILS

BY

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Introduction

Phosphate fixation in the sugar-cane soils of British Guiana has already been investigated by C. L. C. Bourne in 1940, * and a summary of the general subject of phosphate fixation by soils has been prepared by him but not published. Bourne applied several different laboratory methods for the determination of phosphate fixation but mostly employed a modification of A. Floyd Heck's method † for examining the British Guiana soils. This method may briefly be described as follows :—

> Half-a-gram of air-dry soil is intimately mixed with 50 cc. of water or phosphate solution of known concentration and evaporated down to dryness and finally dried at 100°C. The "available" phosphate content is then determined in the treated sample by the Truog coeruleo-molybdate method, § using N/500 sulphuric acid buffered to pH 3.0 with ammonium sulphate. The water treatment serves as a "blank" for determining the available phosphate content of the soil, and the difference between this and the extractable phosphate content of the phosphate-treated soil compared with the total amount of phosphate added gives a measure of phosphate fixation.

The results obtained by Bourne with British Guiana soils showed considerable variation, the degree of fixation ranging from 20 to 90 per cent. The proportion fixed was not affected by the concentration used which lay between 50 and 500 parts P_2O_5 per million parts of soil.

Some of the British Guiana soils were found to be capable of fixing up to the equivalent of three (3) tons of super-phosphate per acre 6-inches of soil under the conditions of the experiment. Moreover, the degree of phosphate fixation was not diminished by liming the soils with ground limestone, even when the final reaction was markedly alkaline, nor by saturating them with exchangeable calcium-ion.

Experimental

(A) Direct Laboratory Measurement by a Conventional Method

Phosphate fixation was first measured in the laboratory on composite samples representing the A-horizon of the profiles examined and sampled by us in British Guiana in January, 1946, at sites selected by Mr. R. R. Follett-Smith.

The main features of these composite samples are given in Table I.

Discussion of Laboratory Data :

> Note : The data in Table I are the actual analytical results obtained with the composite soil samples ; they agree closely with the arithmetical means for the component profile samples.

Each of the soils is very highly *acid* (pH 5.3 or less). *Organic matter* and *nitrogen* contents are fairly high to medium on Trinidad standards, except the sample of true pegasse (No. IX ; Wales (1)), which has an exceptionally high organic content. The Riverside Silt soils contain least organic matter and nitrogen. Carbon-nitrogen ratios are variable but tend generally to be low (less than about 11) in soils other than Pegassy Clay. This denotes either considerable surface erosion or organic wastage or profound biological breakdown of the organic component and a paucity of fresh plant residues (trash). None of the soils is salty except the first two Port Mourant soils (Nos. III and IV) which, however, contain only small and probably harmless amounts of salts (conductivity values not here recorded).

Available phosphate is relatively very low for all except two of the soils, of which one (No. I, Diamond (1)) is near the border-line of phosphate adequacy and the other (No. II Diamond (2)), which is very rich in available phosphate, had probably been recently manured with filter-press mud.

Available potash is generally low, that is, less than the value provisionally accepted as the limit of adequacy for heavy sugar-cane soils (200 p.p.m.). The Riverside Silt soils show greatest potash deficiency.

Lime requirement : This was determined by the Hardy-Lewis electrometric titration

* Some Preliminary Experiments on Phosphate Fixation in British Guiana Sugar-Cane Soils. C. L. C. Bourne. *Sugar Bull.* 10, 1941, Dept. Agric. B.G., pp. 50-61.
† *Soil Sci*., 1934, XXXVII, pp. 477-482.
§ *Journ. Amer. Soc. Agron.*, 1930, XXII, pp. 874-882. See "The Estimation of Readily Available Phosphorus in Soils". C. L. C. Bourne, *Agric. Journ. Brit. Guiana*, 1931, IV, 2, pp. 91-94.

Table I: Laboratory Data for the Soils Examined

Soil-Sample	Sand content %	Index of Texture (I.T.)	Reaction Normal pH	Org. matter content %	Total nitrogen content %	C/N ratio	Avail. P_2O_5 p.p.m. *	Avail. K_2O p.p.m. *	Lime requirement t./ac. 6 ins.
(A) FRONTLAND CLAY									
(III) Pt. Mourant (1)	9	42	5.1	3.8	0.21	10.4	*13*	*170*	3.9
(IV) Pt. Mourant (2)	7	46	5.0	5.3	0.26	11.9	*22*	*156*	4.6
(V) Pt. Mourant (3)	7	40	5.0	3.5	0.21	10.0	*19*	*176*	3.4
(VI) Pt. Mourant (4)	6	42	5.2	3.2	0.19	10.0	*8*	291	2.5
(B) PEGASSY CLAY									
(II) Diamond (2)	10	53	4.5	6.8	0.21	18.5	(384)	216	13.6
(VII) Blairmont (1)	8	45	4.9	5.5	0.27	11.9	*9*	*171*	6.1
(IX) Wales (1)	—	(72)	4.3	85.3	1.11	44.6	*12*	*127*	15.0
(C) RIVERSIDE SILT									
(I) Diamond (1)	7	50	4.7	3.1	0.17	10.7	46	*134*	7.5
(VIII) Blairmont (2)	25	22	5.3	3.0	0.11	(16.5) †	*28*	*110*	1.5
(X) Wales (2)	5	42	4.5	3.1	0.18	10.2	*14*	*101*	6.9

* Values denoting possible inadequacy are *italicized*.
† Contains considerable amounts of charcoal and cane-trash.

method.* The values obtained are expressed in Table I as tons of calcium carbonate required theoretically to raise the reaction of one acre of surface soil, 6 inches deep, to pH 7.2. They range in magnitude from 1.5 to 15 tons per acre and tend to be highest for Pegassy Clay.

Conventional method used for determining phosphate fixation:

This differed only slightly from that used by Bourne. One gram of air-dry soil was mixed into a thin paste with water to which 1 cc. of a solution of acid sodium phosphate ($NaH_2PO_4H_2O$), containing 0.35 mg., P_2O_5 had been added, equivalent to 350 parts P_2O_5 per million parts of air-dry soil. The paste was then evaporated to dryness. A weighed portion was extracted with water in a mechanical shaker, and filtered. Water-soluble phosphate was determined in the filtrate by the coeruleo-molybdate method. The soil residue, after washing in the filter-paper was then similarly extracted with N/500 sulphuric acid (Truog reagent) and the acid-soluble phosphate was likewise determined in the extract. The results obtained are set out in Table II.

Discussion of results (Table II). Each of the composite A-horizon soil samples, with one exception, exhibits a very high degree of phosphate fixation under the conditions of this experiment. There seems to be no significant difference in the phosphate-fixing capacity of the three different soil-types. The mean percentage fixation capacity is 73 percent of that absorbed. The slightly-fixing sample (No. 11, Diamond (2), Pegassy Clay) fixed only 24 percent of the phosphate absorbed but this sample contained a very high initial available phosphate content (384 p.p.m.), presumed to be the result of manuring with filter-press mud. The high values obtained with all the other samples show the same order of magnitude as those recorded by Bourne. They correspond to a fixation in unavailable form of 4 cwt. of P_2O_5 per acre 6 inches of soil, equivalent to about 22 cwt. of superphosphate manure per acre, which is a very large amount indeed according to practical manuring standards.

(B) Measurement After Incubation: Effect of Liming

Phosphate fixation was next measured on samples of the same soils that had been mixed with phosphate solutions both before and after liming. The mixtures were allowed to stand (incubated) in a moist condition for three months with occasional addition of water in order to permit the soils to react fully with the added ingredients. They were then allowed to dry out in the air, and subsamples were taken for the determination of "available" phosphate by the standard Truog method.

Procedure: (a) Unlimed Soils. A large sample (about 500 g.) of the 2 mm. air-dry soil was slowly wetted to field capacity without destroying its aggregate structure and 10 cc. of a solution containing the right amount of mono-calcium hydrogen phosphate ($CaH_4(PO_4)_2$) to supply 360 parts P_2O_5 to one million parts of the air-dry soil were added.

* *Journ. Agric. Sci.*, 1929, XIX, p. 17.

Table II: Results of Conventional Phosphate-Fixation Experiment

(Values are P_2O_5 parts per million of air-dry soil)

	1	2	3	4	5	6	7
	Avail. (Truog) phosphate originally present	Plus 350 ppm. sol. P_2O_5	Water-soluble phosphate extracted	Acid-soluble phosphate (Truog)	Total absorbed phosphate (2-3)	Total fixed phosphate (5-4)	Percentage phosphate fixed of that absorbed %
(A) FRONTLAND CLAY							
(III) Pt. Mourant (1)	13	363	42	82	321	239	74
(IV) Pt. Mourant (2)	22	372	42	106	330	224	68
(V) Pt. Mourant (3)	19	369	32	72	337	265	79
(VI) Pt. Mourant (4)	8	358	37	84	321	237	74
(B) PEGASSY CLAY							
(II) Diamond (2)	384	734	87	494	647	153	24
(VII) Blairmont (1)	9	359	35	77	324	247	76
(IX) Wales (1)	12	362	14	40	348	308	89
(C) RIVERSIDE SILT							
(1) Diamond (1)	46	396	66	122	330	208	63
(VIII) Blairmont (2)	28	378	73	146	305	159	52
(X) Wales (2)	14	364	28	47	336	289	86

(b) Limed Soils. To a similar sample of air-dry soil was first added about 2 g. of powdered gypsum ($CaSO_4$ $2H_2O$). Then an amount of pure precipitated calcium carbonate equal to the full theoretical lime requirement of the soil (Hardy-Lewis method (Table I)) was suspended in water and carbonic oxide gas passed in until most had dissolved to form calcium bicarbonate. The bicarbonate solution was then added slowly to the gypsum-treated soil, care being taken not to destroy its natural aggregate structure. Water was finally added to wet the soil to field capacity.

The treated soil samples, after 3 months' storage (incubation) at ordinary temperature with periodic addition of water to keep them at field-capacity moistness, were subsampled with a cork borer after they had dried out. The available phosphate contents of the subsamples were then determined by the Truog method. The results obtained for limed and unlimed soils are given in Table III; they are means for duplicate trials. The Truog values include water-soluble phosphate which was not separately determined in this incubation experiment.

Discussion of results (Table III). The degree of phosphate fixation under incubation conditions without liming, involving 3 months' storage, does not appreciably differ for these composite soil samples from that manifest under the laboratory conditions imposed by the conventional procedure (Table II). The magnitudes of the percentage values obtained are very similar. The comparable means are 73 percent (Table II) and 78 percent (Table III).

The degree of phosphate fixation *after liming* and incubating is not very much less than that attained without liming, 67 percent as against 78 per cent (Table III). This result resembles that obtained by Bourne in his laboratory liming experiments using a conventional method.

The fact that, in our experiments, as well as in Bourne's, liming failed materially to reduce phosphate fixation by British Guiana sugar-cane soils is difficult to explain in terms of the modern theory of phosphate fixation which assumes that the chief seat of fixation is the active surface of hydrous iron oxide or hydrous alumina, or the residual valency points originating in the iron and aluminium constituents of the ionic crystal lattice of certain clay minerals, for example, ferriferous kaolinite. When the active surfaces or points are occupied by hydroxyl-ion, introduced into the soil-system by liming, then, in theory, the massive absorption of phosphate should be prohibited, except in-so-far as acid exchange may proceed until the stage when equilibrium has been established between hydroxyl-ion and phosphate-ion. Silicate-ion is believed to act similarly in this respect, so that both liming and silication should be equally efficacious as practical means of reducing phosphate fixation by soils in the field.

Perhaps in our laboratory experiment the failure of liming to diminish phosphate fixation may be attributed to incomplete neutralisation of the various soil acids present, for it will be remembered that, in the liming process, gypsum and calcium bicarbonate were used, both of which generate acid when they react with the soil. Indeed, determination of final reactions proved that this actually was the case; in no instance was the final normal pH value greater than pH 6.1.

Table III: Results of Phosphate-Fixation Experiments with Unlimed and Limed Soils after Incubation

(Values are P_2O_5 parts per million of air-dry soil)

	Without phosphate	With phosphate added (360 ppm.)	With lime and phosphate added (360 ppm.)	Phosphate absorbed		Percent phosphate absorbed	
				Without lime	With lime	Without lime	With lime
	Truog values;		p.p.m.	p.p.m.	p.p.m.	percent	percent
(A) FRONTLAND CLAY							
(III) Pt. Mourant (1)	8	81	114	287	254	78	68
(IV) Pt. Mourant (2)	10	70	141	300	229	81	62
(V) Pt. Mourant (3)	4	77	118	287	246	79	67
(VI) Pt. Mourant (4)	11	81	102	290	269	78	73
(B) PEGASSY CLAY							
(II) Diamond (2)	437	668	419	129	378	16	47
(VII) Blairmont (1)	4	81	102	283	262	78	72
(IX) Wales (1)	-	-	-	-	-	-	-
(C) RIVERSIDE SILT							
(I) Diamond (1)	50	141	139	269	271	66	66
(VIII) Blairmont (2)	16	70	190	306	186	81	49
(X) Wales (2)	8	74	82	294	286	80	77

Summary and Conclusions

(1) A marked capacity to fix added soluble phosphate has been demonstrated for surface (A-horizon) samples of soil representative of Frontland Clay, Pegassy Clay and Riverside Silt soil-types which comprise most of the sugar-cane lands of British Guiana.

(2) Two laboratory methods have been used in this investigation. The results obtained by the first (a conventional procedure) have corroborated previous results obtained by C. L. C. Bourne (1941); they showed a degree of phosphate fixation around 73 percent of that absorbed (or 65 percent of that added).

(3) The second method involved a three-months' incubation period of the moist phosphate-treated soil. In one set, the soil samples were treated with gypsum and calcium bicarbonate; in another set they were not treated with lime. In both cases the degree of phosphate fixation was high, namely, 78 percent of the amount of phosphate added for the unlimed mixtures and 67 percent for the limed mixtures. This last result also agrees with Bourne's findings for limed soil.

(4) The high degree of phosphate fixation shown by limed soils is unexpected; theory indicates that liming should reduce phosphate fixation. Failure to do so in our experiments may perhaps be attributed to the fact that the final mixture was not alkaline nor even neutral in reaction.

(5) The experiment with limed soil consequently should be repeated, using calcium hydroxide (slaked lime) in preference to calcium carbonate or bicarbonate and in sufficient quantity so as to effect complete neutralisation of the soil acids, and allowing sufficient time for the interaction between the soil acids and the lime to proceed to completion before adding phosphate.

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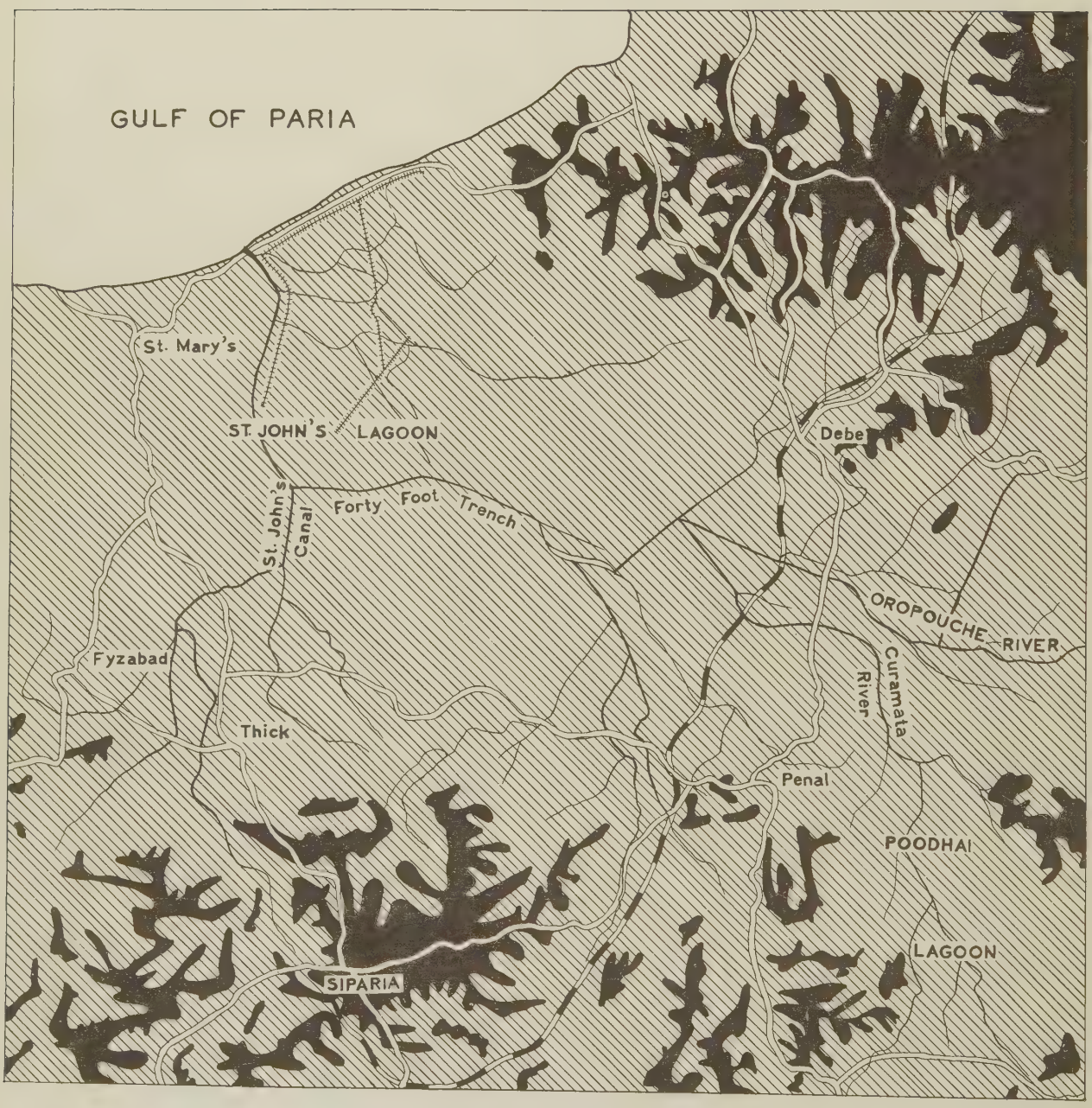
The Editor is prepared to consider signed articles for publication in *Tropical Agriculture*. Such articles should normally vary between 1,000 to 6,000 words and may be illustrated if desired.

FIG. 1

OROPOUCHE LAGOON



PEASANT FARMING IN TWO DISTRICTS OF THE OROPOUCHE LAGOON JUNE 1944–5

Report on An Economic Survey

BY

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District

The Oropouche "lagoon" occupies about 50 square miles in the south-west of Trinidad just south of San Fernando (see Figure 1). (In Trinidad the word "lagoon" means a drained or partly reclaimed swamp). The lagoon consists of a long narrow strip of alluvial flats bounded and encroached on by an intricate system of low convolute hills. The lagoon land is practically treeless, whereas the surrounding upland is planted in cacao and other tree crops. A road system winds along the uplands bordering the edge of the lagoon.

The rainfall of the area is comparatively low, and rarely exceeds 80 inches per annum; the dry season is usually unbroken except for a few scattered showers, and extends from about January — May. The wet season is characterised by heavy tropical downpours which make the satisfactory drainage of the lagoon land very difficult. The area is drained by one sluggish stream, the Oropouche, which traverses a distance of about 12 miles with little or no appreciable fall. The drainage system, particularly at the lower end of the lagoon, has been improved from time to time; a number of canals have been cut and a sea wall with a sluice has been constructed at the main outlet. It appeared at the time of the survey that the drainage system was working far from satisfactorily and some crops were lost due to flooding.

The soils of the Oropouche and neighbouring area have been sampled by Hardy, Duthie and Rodriguez. [1] The lagoon soil generally consists of heavy non-calcareous clay; it is highly acidic with a medium to high organic matter content; it contains an adequate supply of phosphates, but is deficient in potash. The surrounding uplands consist of Moruga Yellow Sand and Moruga Yellow Silt (both recently renamed Marper Silt). [2] The two soils are indeed similar in most respects: they are markedly acidic with a medium to high organic matter content; they are deficient in both potash and phosphates. It will be seen below that the lagoon land is far more productive than the upland; the upland as a cacao soil has been shown of low productivity. [3]

Long distance communications in the district are good. The Trinidad Government Railway runs through the heart of the area and has stations at Debe, Penal and Siparia. The main southern road from San Fernando to Siparia also runs through the district. Short distance communications are, however, very poor because of the difficulty of maintaining roads on the lagoon. In order to obtain access to a certain plot of lagoon land, it is often necessary to travel two or three times the direct distance on the tortuous road skirting the lagoon. Partly on account of poor internal communications in the lagoon no animal drawn implements are used in the cultivation of crops. Although the district appears very rural, it is situated in the oil field area; there are oil wells on the lagoon land around Barrackpore, and headquarters of oil companies at Fyzabad, Point Fortin and La Brea. The only oil field employment obtained by the peasants interviewed was at Fyzabad.

The population of Oropouche is exclusively East Indian. The history of the population is similar to that in Bejucal, [4] except that most of the land in the area was evidently privately owned before the present peasant farmers established themselves.

Two lagoons (that is, two comparatively isolated "bays" of the whole lagoon) were surveyed, one known as St. John's Lagoon, and the other Poodhai (see Figure 1). These two lagoons were selected as likely to give instructive contrasts in the types of Oropouche farming. It can be seen below that the contrasts were not as marked as originally assumed. Both lagoons appear to be similar in being rural backwaters of the area; the farmers are undoubtedly less enterprising than farmers for instance in Penal and Debe, the centres of water-melon and vegetable production.

(1) Hardy, F., Duthie, D. W., and Rodrigues, G. The Cacao and Forest Soils of Trinidad (D) South Central District. Trinidad Government Printer, Port-of-Spain, 1936.

(2) Hardy, F., and Chenery, E. M. A Tentative Scheme for the Classification of Soils of Trinidad. *Tropical Agriculture, Trin.*, Vol. XVII, No. 8, 1939.

(3) Shephard, C. Y. The Cacao Industry of Trinidad Series II. Trinidad Government Printer, 1936.

(4) Jolly, A. L. Peasant Farming in the Bejucal Area of Trinidad. *Tropical Agriculture, Trin.*, Vol. XXII, No. 5.

Land Utilisation

The 83 holdings surveyed occupied 358 acres, 39 acres of which were rented out to tenants. Fifty-one per cent. of the area was situated in the Poodhai Lagoon and forty-nine per cent. in St. John. The average size of holdings was 4.3 acres or only about half the average in Bejucal. Holdings in Poodhai were larger (5.2 acres) than in St. John (3.7 acres).

The characteristic of holdings in Oropouche is that they consist of two types of land. The Upland rises 25 to 50 feet above the bed of the Lagoon; this land is used for the housespot, for the housing of livestock and the cultivation of provisions; a large part of this Upland is at present semi-abandoned cacao and coffee plantations. On the Lagoon land rice is planted in the wet season and in the dry, such crops as peas, corn and vegetables are usually grown. On most holdings the two types of land are quite distinct and are often widely separated; for instance, the average distance of Upland lots from the house was 0.1 mile, whereas Lagoon land was on an average of 0.6 miles. On the average holding about half the land was Upland and half Lagoon; on all but one holding (claimed as 100% lagoon) both types of land were operated. Within each lagoon there was a tendency for large holdings to consist more of Upland and less Lagoon than small holdings, but there was little difference in the average distribution in Poodhai and St. John.

Far more of the Lagoon land was rented by farmers than Upland: Fifty-two per cent. of Lagoon land and only eleven per cent. of the Upland was rented. Overall thirty-one per cent. of the area was owned and sixty-nine per cent. was rented. It is not true, however, to say that the farming in these two lagoons consisted mainly of owner-occupier production. The income from owned land ($33 per acre) was far lower than the income from rented land ($118 per acre), so that only thirty-nine per cent. of the total crop income was derived from owned land.

Table 1 shows the strikingly different incomes obtained from various types of land utilisation. None of the income figures appear high compared with previous surveys and there are obviously some surprising differences. The income from cacao and coffee lands was extremely low due to the fact that most of these lands were already abandoned at the time of the survey; most of the little income was derived from coffee bushes interplanted in the cacao. Cacao was rarely harvested because of low yield and the depredation of animal pests which had increased due to the shortage of poison bait and ammunition during the war. It is possible that with easier supply conditions some cacao will be reaped, but the state of cultivation and the normal yields of the district indicate that estate standards of profitable cultivation is unlikely to be achieved.

It appears that these peasants settled first on the Upland on which cacao and coffee is now planted; that the decreasing yields and prices of cacao during the 1920's and 30's gradually forced them to turn more attention to the Lagoon land. It has been found that cacao lots have been operated by the present proprietors for an average of fifteen years, Lagoon land on the average for only nine years.

The income from cacao and coffee lots was so low and the acreage so large (33% of the total) that it has been considered necessary to class these lands as uncultivated. Added to these lands were areas of grazing and uncultiva-

TABLE 1

Land Utilisation

	Acreage			%	Gross Income per
	Owned	Rented	Total	Owned	Acre of Crop
Rice (and dry season Crops) on Rice Lands	42	86	128	33	$ 132
Provisions	20	18	38	52	$ 84
Cane	3	—	3	100	$ 13
Total Cultivated	65	104	169	38	
Cacao & Coffee	120	—	120	100	$ 5
Uncultivated	13	4	17	80	—
Grazing	12	1	13	90	—
Rented out *	39	—	39	100	$ 88
Total Uncultivated	184	5	189	97	
Total Acreage	249	109	358	69	

* Mainly houselots.

ted land so that the total of all land not cultivated made up a surprisingly large proportion of the whole holding. It can be seen from Table 1 that there was actually more land uncultivated than under cultivation and that of the owned land there was nearly three times as much uncultivated as cultivated. These uncultivated lands were used to some extent by the farmers in supplying grazing and cut grass for livestock and as a foraging ground for poultry. However, none or extremely little of these uncultivated lands were in fact uncultivable as is evidenced by the fact that small adjacent patches were cultivated in provisions.

Table 1 indicates the extent to which the crop farming of these peasants were concentrated on rice (Lagoon) land: 76% of the cultivated area was under rice and 81% of the crop income was the produce of rice land. (Table 2). Even so, the whole of these rich lands was not fully cultivated: 24½ acres or 20% remained uncultivated in the dry season. The reasons given for not cultivating were that the land was too wet for planting (45% of the area) and that insufficient labour was available when conditions were suitable for planting (33% of the area). These two reasons are probably one and the same in that water remaining on the land at the end of the wet season allowed only a short planting period to achieve which sufficient labour was not for some reason employed.

The general position regarding land utilisation was therefore somewhat peculiar: On the average holding of about 4 1/3 acres, 2 1/3 acres were uncultivated or under semi-abandoned cacao and coffee, 1/3 of an acre more was not cultivated in the dry season; thus the peasant had about 2½ acres of cultivable land which he used little or not at all. It can be seen in the next section that the non-cultivation of such a large amount of land was not due to a shortage of man-power. These farmers had more time available for work on the land they did cultivate than was available either in Bejucal or La Pastora. In addition to ample time available on the holding, the Oropouche farmer spent about as much time away from the holding as the farmers of the previous two surveys.

Family

The population in Oropouche is exclusively East Indian and, as would be expected, the families there are similar to those in Bejucal. The average size of family was six persons, which represented four consumer equivalents, 63% of whom were workers. School boys and school girls, classed as non-workers, gave casual assistance on the holding in cutting grass for livestock and assisting in the field, particularly during the rice planting season. The total labour force was 750 man-days per annum or the equivalent to one man and two women full time; 294 of these man-days, or 39%, were available for work on the holding. The man-days available for holding work were fairly evenly divided between wet season — July to December, 150 man-days — and dry season — January to June, 144 man-days, the small difference being due mainly to juvenile help. This family labour supply was ample : the average of 135 man-days available per cultivated acre was far higher than Bejucal (47 man-days) and higher even than on the 2½ acre holdings at La Pastora (112 man-days) (5). This fact was surprising considering the relatively low income per acre from Oropouche holdings (see below). As a result, the gross agricultural income per man-day available was only $1.40 in Oropouche compared with $2.45 in Bejucal and $2.90 at La Pastora. There was evidence, therefore, of inadequate regular employment on holdings in Oropouche, probably due to unbalanced labour requirements from month to month.

Men contributed 70% of the labour available for holdings and women 30%; women spent one-third of their time in field work; this latter proportion is higher than recorded in two previous surveys and is further evidence of unbalanced labour requirements.

Income and Expenditure

The total income of $850 per family in Oropouche was considerably less than the $1,200 recorded in previous surveys. $410 or 49% of the Oropouche income was obtained from

TABLE 2

Income Per Holding ($)

	Poodhai	St.John's	Both Lagoons
Rice	95	121	110
Ground Provisions	48	29	37
Cacao & Coffee	8	5	6
Sugar Cane	1	—	1
Dry Season Crops	41	108	80
Livestock	146	125	134
Livestock Products	65	30	44
Total Agricultural	404	418	412
Wages, Peasants	65	68	67
„ Oil Fields	29	234	147
„ Other Employment	133	52	86
Profits from Business	15	58	40
Profits from Timber Cutting	119	—	50
Gifts, Loans, Rents, Etc.	42	51	48
Total Non-Agricultural	403	463	438
Total Income	807	881	850

(5) Jolly, A. L. Peasant Agriculture — An Economic Survey on La Pastora Land Settlement. *Tropical Agriculture, Trin.*, Vol. XXIII, No. 7.

the holding; agricultural activities away from the holding contributed 8% of the income and consisted entirely of wage earnings with other peasants; 25% of these wages were paid for by exchange labour. Thus, 57% of the income was derived from agricultural occupations, and it is rather surprising that in a comparatively rural district with cultivable land available, agriculture should contribute a smaller proportion of the total income than has been found in the two districts nearer Port-of-Spain. In Bejucal, 70% of the total income was derived from agricultural occupations and in La Pastora 66% was so derived.

The avenues of non-agricultural employment in Oropouche were different in the two lagoons; in Poodhai, the main sources of non-agricultural employment were labouring chiefly for the Public Works Department (16%) and cutting and selling timber from the Southern Water Shed Reserve (15% of the total income); neither of these two types of employment was continuous throughout the year; a few days a week could be obtained intermittently from them. In St. John's Lagoon, the Fyzabad Oilfields contributed most of the non-agricultural employment (26% of the total income); Oilfields employment was usually regular throughout the year and was taken either by one member of a large family or by a man with a holding small enough to be worked after hours and at week-ends. Earnings off the holding were, however, similar in the two lagoons, Poodhai $403 per family, St. John's $463. It would appear from Table 3 that on the whole earnings off the holding were only slightly more remunerative than those derived from the holding, but the slight tendency was in fact made up by reverse trends in the two lagoons; in Poodhai there was a tendency for earnings to increase as the larger proportion of the total was derived from the holding; in St. John's there was a more marked association in the opposite direction, as the percentage of off-holding income increased the total earnings also increased. This difference was explained by the fact that the Oilfields rate of wages averaged about $2.00 per day or higher than other occupations. Twenty-eight of the 83 families relied on their holdings to the extent of between 50 to 60% of their total income; there were very few families who occupied their holdings as residences rather than farms; only two families derived less than 20% of their total income from their holdings; only five families derived more than 80% of their income from the holding.

The average agricultural income was $412 per holding, or $204 per *cultivated* acre; this latter figure appears to be high by comparison with the previous surveys but is inflated by an unusually large volume of sales of livestock and livestock products. $179.00 per holding or 43% of the agricultural income was derived from livestock, a far higher income than in Bejucal ($53.00 per holding); actually, the percentage contribution of livestock to the agricultural income in Oropouche was greater even than for La Pastora (36%).

The crop income in Oropouche was $114.00 per acre which was only slightly higher than Bejucal ($110.00 per cultivated acre), in spite of the fact that only the sugar cane land in Bejucal was continuously cropped for the whole year. The crop income in St. John's Lagoon, $139.00 per cultivated acre, was far higher than in Poodhai, $87.00. The difference, it can be seen in Table 2, was mainly as to dry season production in respect of which Poodhai was $67.00 less than St. John's. Livestock production, on the other hand, was higher in Poodhai, $211.00 per holding, than in St. John, $155.00. The resultant difference in the total agricultural incomes of the two lagoons was very small.

Two-thirds of the agricultural income was cash and one-third consumed or utilised on the

TABLE 3

Relationship Between Total Earnings and Employment Away From Holding

% Of Income Derived Away From Holding	60% & Over	40 — 59%	Under 40%	All
Both Lagoons:				
No. of Families	28	36	19	83
Total Income per Family	$ 850	$ 900	$ 750	$ 850
Total Income per Total Man-day	$1.19	$1.12	$1.07	$1.13
Poodhai Lagoon:				
No. of Families	11	14	10	35
Total Income per Family	$ 670	$ 930	$ 790	$ 810
Total Income per Total Man-day	$0.94	$1.04	$1.11	$1.03
St. John's Lagoon:				
No. of Families	17	22	9	48
Total Income per Family	$ 970	$ 880	$ 700	$ 880
Total Income per Total Man-day	$1.36	$1.19	$1.02	$1.22

holding ; these proportions were similar to Bejucal. There were no large or distinctive cash crops in Oropouche similar to cane or eddoes

TABLE 4

Livestock (Cattle Units) Per Holding

	Poodhai	St. John's	Both Lagoons
Draft Animals (including Oxen)	0.43	0.17	0.28
Cattle	1.50	1.34	1.41
Goats & Pigs	0.13	0.07	0.10
Poultry	0.39	0.43	0.41
Total	2.45	2.01	2.20

in Bejucal. The mixture of dry season crops in Oropouche was predominantly cash crops, 85% of the production being sold, but collectively these crops contributed only 19% of the agricultural income. The main subsistence crop was rice, 70% of which was consumed ; this consumption represented $75.00 per family per annum, or about 60 pounds paddy per consumer equivalent per annum. Rice was by far the largest item of food expenditure and represented 20% of the total food and 57% of the total food provided by the holding. The next most important subsistence crop was ground provisions, 46% of which were consumed. Ground provisions contributed about 4% of the total food expenditure. Corn was grown extensively for poultry feed, and 80% of the production was fed to stock. Livestock enterprises were operated much more for cash income in Oropouche than in Bejucal ; in Oropouche 75% of the livestock income was from cash sales ; in Bejucal only 42% represented sales.

The agricultural expenditure of $37.00 per cultivated acre was similar in total to Bejucal. Labour was the largest item and represented 60% of the total ; a far higher proportion of this labour (36%) was remunerated by exchange than in the two other surveys. Expenditure on feeding stuffs appeared to be at about the same rate as Bejucal, at $4.00 per cattle unit per annum. The only really remarkable feature of the expenditure was the absence of manure ; no record could be obtained of any manure being applied in known quantities ; none was used on the lagoon land for rice or dry season crops, and the manure from pens near the house was evidently scattered indiscriminately over provision lots and abandoned cacao cultivations.

It would appear, through this general discussion of conditions, that the Oropouche farmers of the sample were less agricultural and pursued more of a subsistence type of crop farming than the previous two districts surveyed. Their cash farming was restricted largely to livestock and dry season cropping.

Livestock

The average number of livestock was 2.20 Cattle Units or 1.03 per cultivated acre. The average per cultivated acre is, however, of little significance since stock management was very little associated with crop husbandry ; animals were kept for the most part on the uncultivated area of Upland ; draft animals were not used at all for the cultivation of land ; with the exception of poultry no feeding stuffs for stock were grown on the holding. In fact, the growing of corn for the poultry which amounted to 62% of the food expenditure on livestock was the only mixed farming feature on these holdings in spite of the fact that both livestock husbandry and crop cultivation were practised.

The heavier livestock population and the larger livestock income in Poodhai as compared with St. John has been noted in the previous section. The difference was due chiefly to the number of draft animals which were used by the Poodhai farmer for hauling timber which was one large source of income away from the holding in that lagoon. Oxen were used chiefly for this purpose and the 35 Poodhai farmers owned 11 of these animals whereas the 48 St. John farmers owned only four.

Seventy-four per cent. of the total livestock units consisted of cattle, seven per cent. goats and pigs and nineteen per cent. poultry. The method of converting animals to livestock units, which was based mainly on capital value, grossly underestimates the extent of poultry enterprise among these farmers. Poultry contributed 56% of the livestock income and incurred 81% of the feed expenditure (excluding grazing and greenmeat). The conventional livestock units, therefore, do not seem well suited for livestock management by peasants in the tropics. A conversion rate of between 25 and 50 hens per unit seems more suitable than the 100 hens adopted. This point is brought out when the income per $1 invested in poultry is compared with other types of livestock ; the average

TABLE 5

Variation in Livestock Population (Cattle Units per Holding)

Cattle Units Per Holding	0 — 0.99	1.00 — 2.99	3.00 & Over	All
No. of Holdings	24	38	21	83
Draft Animals	0.02	0.14	0.83	0.28
Cattle	0.06	1.46	2.87	1.41
Goats & Pigs	0.03	0.11	0.15	0.10
Poultry	0.37	0.35	0.55	0.41
Total	0.48	2.06	4.40	2.20

income on these holdings was $4.16 for poultry per $1 valuation of poultry compared with only 41¢ per $1 invested in other types of stock.

Poultry is usually the first choice of the peasant as a livestock investment. The advantage of a small unit of stock makes it possible for the small farmer to make an investment according to his small capital. It can be seen from Table 5, however, that 60 birds per holding was about the maximum that any farmer kept; all but one farmer (with no stock at all) kept poultry, but only eight of the 83 kept more than .60 units of poultry or a flock of about 40 breeding birds. The subsequent investments in livestock were chiefly in respect of cattle. These large units of stock have no doubt the advantage of giving the owner some social distinction, but they have also the economic advantage of requiring simpler management particularly as regards feeding than poultry.

In spite of the livestock farming in Oropouche being large in relation to the crop farming, there was little evidence of methodical livestock management. On many questions farmers were vague and had evidently few standards of output at which they aimed. For instance, with poultry it was impossible to obtain data relating to egg production or even to hatching; the only information that a farmer could give with any assurance was the number of birds he had on his holding and about how many eggs and poultry he sold during the year. Although $4 per $1 invested in poultry was a far higher income than from the other types of stock, it was actually very low; it was the equivalent of about one bird sold ($2 to $2.50), one bird consumed ($1) and one dozen eggs sold per hen in flock per annum.

In the case of cattle, a total of 96 cows was recorded at the beginning of the year and yet total births were only 55, an average breeding period of once in one year and nine months (exclusive of twins). With an initial herd of 42 goats, the net increase was only 46, a birth rate of 1.1 per head per annum. These figures, although poor by other agricultural standards, were no worse than for other peasant holdings, probably due to the rather peculiar attitude of peasants to livestock. With livestock involving little upkeep expenditure, any produce or progeny over and above upkeep cost is considered more in the nature of a lucky windfall than a return on capital invested.

Rice Cultivation

On some lots rice was the only crop for the year and on others it shared the land with dry season crops. It can be seen from Table 6 that there was little difference between the two types of rice land; in most particulars they corresponded very closely.

The cultivation of rice in Oropouche was much more similar to rice in Bejucal than the cultivation of other crops in the two districts. In Bejucal both income and costs were somewhat higher, but the net income in the two districts was very similar; the wide distribution of net income was also similar. The lower average earnings per man-day in Oropouche were due to the large number of man-days available per acre, but this difference in days was not so large for rice as other crops. (The average number of man-days per cultivated acre of all crops was nearly three times as high in Oropouche as in Bejucal). The higher gross income in Bejucal was due to the inclusion of urdi in the income and difference in the price of rice, (3.8 cents per

TABLE 6

Comparison of Costs and Income of Rice Grown (1) As Sole Crop and (2) In Rotation With Dry Season Crops ($ per Acre)

	Rice Grown As:		All Rice	All Rice Bejucal
	Sole Crop	In Rotation		
Acreage	24	104	128	251
$ per Acre				
Income	78	83	81	94
Hired Labour				
Preliminary Cultivation	3 °	4 +	4 ‡	11 *
Planting	7 °	6 +	6 ‡	7 *
After Cultivation	—	—	—	1 *
Harvesting & Milling	12 °	17 +	15 ‡	18 *
Total Labour	22	27	26	39
Rent	5	3	3	5
Seed	3	2	3	4
Total Cost	30	33	32	48
Net Income	48	50	49	46
Family Man-days Available	74	81	78	63
Net Income per Man-day Available	$0.68	$0.55	$0.63	$0.72

Average of ° 21 acres + 95 acres ‡ 116 acres * 118 acres.

TABLE 7

Family and Hired Labour for Rice Cultivation

Family Man-Days Available per Acre	1 — 29	30 — 39	40 — 49	50 — 59	60 — 79	80 & Over	All
Hired Labour Cost per Acre ($)	36	30	19	18	37	27	26

lb. in Bejucal, 3.2 cents per lb. in Oropouche) ; the difference in the price of rice was due to different charges for home-grown rice (3.5 cents and 3.12 cents ($5.00 per 160 lbs.) respectively), and the higher selling price in Bejucal, due to the acute shortage of rice during that survey year. Actually, the yield in Oropouche (2,560 lbs. paddy per acre) was slightly higher than in Bejucal (2,420 lbs.).

The higher expenditure in Bejucal was due mainly to the cost of hired labour for preliminary cultivations, attributable to ploughing, much of which was hired ; all operations in Oropouche were done by hand and preliminary cultivation consisted mainly of cutlassing and rough hoeing when the land was sufficiently wet. Oropouche peasants strongly disfavoured ploughing or any cultivation which involved turning the soil ; they claimed that within a few inches of the surface the soil was very sour and infertile. The difference in operations probably accounted for the somewhat higher family labour available in Oropouche as well as the lower cost of hired labour ; all of the operations in Oropouche could be performed by family labour, whereas a farmer in Bejucal without a plough had to resort to hiring. The total input of all labour was probably similar in the two districts. It should however be stressed that the expenditure on rice cultivations in Oropouche was far and away the heaviest of any other crop in that district ; the average of $32.00 an acre compares with an average for other crops of only $7.00 an acre.

The characteristics of variable costs and profits and the lack of correlation between family and hired labour noted in the cultivation of rice in Bejucal apply equally to Oropouche. When rice lots were classified according to net income (similar to Table 7), (4) it was found that Oropouche costs varied from $60.00 to $15.00 per acre ; in Bejucal they varied from $72.00 to $27.00. The net income was similarly distributed over a wide range ; 50% of the Oropouche rice lands earned a net income spread over a range of $0 to $49.00 per acre ; in Bejucal 49% of the area was spread over this range. Table 7 indicates a similar lack of correlation between the employment of hired labour and the supply of family labour.

TABLE 8

The Relative Importance of Rice in the Crop Farming of Oropouche and Bejucal

	Oropouche	Bejucal
Rice Acreage as % of Total Cultivated	76	27
Rice Income as % of Crop Income	54	23
Expenditure on Rice as % of Crop Expenditure	77	34

The conclusion regarding the rice cultivation in Bejucal, therefore, apparently applies equally to rice cultivations in Oropouche : " Indeed, rice growing appears to be much more a part of the peasant's family life than of his business activities as a farmer ". It should however be emphasised that, whereas in Bejucal rice was only one of three equally important crops, in Oropouche rice farming comprised the bulk of the cultivation. (See Table 8). It is obviously a weakness of the crop farming in Oropouche that the large crop for which reasonable output was obtained was naturally a household and not a commercial one.

Provision Cultivation

The cultivation of provisions in Oropouche was much more like " the old system " at La Pastora than the cultivation of provisions in Bejucal. Provisions cultivated in Bejucal were characterized by a high gross income ($174 an acre), and high labour expenditure ($25 an acre) ; in Oropouche the gross income was only $84.00 and the labour expenditure $2.00 an acre. Only half of the small labour cost in Oropouche was expended on preliminary and planting cultivations ; in Bejucal 71% of the total labour costs was on these operations. Indeed, provision cultivations in Oropouche did not consist of an annual replanting of the provision areas, but more the maintenance of a permanent stand in starchy root crops.

Table 9 indicates a wide distribution in the net income derived from provision lots. Part of this variation apparently was due to a difference in cost ; this difference is not due to different standards of cultivation so much as to the incidence of rent : many of the provision lots were, in fact, house spots with provisions planted in the garden ; the rentals for these spots were naturally far higher than for ordinary agricultural land. By comparing the expenditure on

TABLE 9

Provision Lots Classified According to Net Income per Acre
($ per Acre)

Net Income per Acre	Under $50	$50 to $99	$100 & Over	All	Poodhai Selling more than 50%
Acreage	7.8	19.8	10.1	37.7	12.0
$ per Acre					
Income	45	74	135	84	100
Hired Labour	1	1	5	2	7
Total Cost	11	5	9	7	8
Net Income	34	69	126	77	92
Family Man-days Available	88	102	124	105	72
Net Income per Man-days Available	$0.39	$0.66	$1.02	$0.73	$1.29

labour by net income groups, it can be seen that high net income was associated with above-average expenditure on labour; indeed, it was only on the lots where labour was employed at the rate of $5.00 an acre that family labour earnings were comparable to ordinary wages rates. It can be seen in the lowest net income group that the earnings per man-day represented nothing like the commercial cultivation of the lots; the provisions were in fact merely consumed in the household. It was largely due to the partly uncommercial nature of provisions cultivation that the average gross income was not far higher than $84.00 per acre. This figure cannot be considered anything like full cultivation when it is remembered that the gross income from provisions in Bejucal was $174.00 per acre.

There appears to be only one section of the peasants interviewed who cultivated provisions on a commercial basis. In Poodhai, 12 acres (32% of the total of both lagoons) were under provisions from which more than 50% of the produce was sold. It can be seen from Table 9 that the gross income of these farmers was $100.00 per acre and the earnings per man-day available were the reasonable figure of $1.29; corresponding provision sellers in St. John netted only $0.59 per man-day available. The Poodhai provision sellers were exceptional in employing labour to the extent of $7.00 per acre; their expenditure represented no less than 97% of all labour employed on provisions in the two lagoons. It can be seen from Table 10 that the only important difference between the Poodhai provision sellers and the rest was that they were more dependent on farming, and particularly on crop farming than the average; that they had a larger area of provisions and made far more productive use of their farming time than the average. It would appear that these farmers were making some effort to solve the problem of irregular labour demands from the excessive rice cultivations by growing provisions in a commercial way.

DRY SEASON CROPS

The dry season crops have been noted as the major cash crops of both lagoons; 85% of the dry season production was sold compared with only 37% of other crops. The largest individual dry season crop was corn, which made up about a third of the total; peas

TABLE 10

Characteristics of Poodhai Provision Sellers

	POODHAI		BOTH LAGOONS
	Selling more than 50% of Provision crop	Whole Lagoon	
Cultivated Acreage per Holding	2.95	2.20	2.04
Provision Acreage per Holding	1.09	0.54	0.45
% Acreage Cultivated	48%	43%	47%
Total Income per Holding	$690	$811	$850
Agricultural Income as % Total Income	63%	50%	48%
Crop Income as % of Agricultural Income	59%	48%	57%
Net Agricultural Income per Man-day Available	$1.54	$1.30	$1.27

TABLE 11

Composition of Dry Season Crops

NET INCOME PER ACRE	Under $25	$25 — $49	$50 — $99	$100 & Over	ALL
Acreage	31	23	33	17	104
% of Dry Season Crop Income from :					
Corn	26	49	51	21	37
Peas	70	37	19	9	22
Water Melon	1	4	13	38	21
Tomatoes	2	9	16	22	16
Others	1	1	1	10	4
Wastage per $ Income	$1.67	$0.29	$0.13	$0.08	$0.24

included a variety of legumes, black eye peas, "gub-gub", "bodi", salad beans, etc., most of which were grown for dry seeds, but a little (particularly in "bodi") was sold as green vegetables; tomatoes and water melon were important crops and there were also a variety of miscellaneous crops such as urdi, pumpkin, cucumber, etc. There appeared to be no recognized system of planting and a variety of inter-cropping was practised. Cultivation was simple in the extreme; "holes" were broken with a cutlass or hoe and seeds were planted in them; much weeding was not necessary since the crop seeds planted in the moist soil soon covered the ground with herbage.

In view of the fact that these crops were grown mainly for cash, one would expect high income and probably high expenditure to be characteristic. This, however, was not the case. The average income as shown in Table 12 was only $63.00 per acre (less than rice or provisions) and total expenditure was only $6.00, i.e., less than any other crop. Even more surprising was the fact that only $3.00 per acre was spent on labour, in spite of the fact that there was as great a scope for the profitable employment of labour on these than in any other crops for the following reasons: first, these crops above all require planting and harvesting within narrow limits of time to obtain the best results; second, 10% of the land used for rice remained uncultivated during the dry season; third, the supply of family labour during the dry season crops was not abundant, being 73 man-days per acre or lower than for any other crop; fourth, successful dry season cultivations gave scope for higher earnings than any other crop. For these four reasons, it would appear that the employment of hired labour was most desirable. It cannot be argued that labour was not available, seeing that an expenditure of $26.00 per acre was incurred for labour on rice cultivations.

The scope for high income and high earnings with dry season crops is shown clearly in Table 12. The earnings of the highest net income group ($1.52 per man-day available) were equalled only by the most successful provision growers in Poodhai. The fact, however, was that much of the dry season crop lands earned pitifully low incomes and the overall range was tremendous. The gross income of individual lots varied from nothing to over $300.00 per acre; 30% of the whole was cultivated at a net income of less than $25.00 per acre; 16% at a net income of more than $100.00 per acre. This variation in net income was in no way due to variation in costs of labour and other items; virtually, every lot of dry season crop was cultivated at negligible expenditure; only 3½ acres out of 104 incurred costs of more than $20.00 per acre.

TABLE 12

Income & Expenditure on Dry Season Cultivations

($ per Acre)

NET INCOME PER ACRE	Under $25	$25 — $49	$50 — $99	$100 & Over	ALL
Income	14	42	76	154	63
Hired Labour	3	2	2	5	3
Total Cost	6	6	5	8	6
Net Income	8	36	71	146	57
Family Man-Days Available	66	79	68	90	73
Net Income per Man-Day Available	$0.13	$0.46	$1.04	$1.52	$0.78

This variation in income was due to two factors: (1) the choice of crops grown, and (2) the success with which they were harvested. It can be seen in Table 11 that a relatively high proportion of water melon and tomatoes harvested was associated with high net income. But equally important was the amount of produce wasted at harvesting time because of heavy rains and flooding. In the lowest net income group, for every dollar's worth of produce harvested an estimate of $1.60 worth spoiled in the field. The wastage in Poodhai was due to early rains and poor drainage conditions; in St. John's there was some wastage due to salt water flooding owing to poor control of the sluices on the sea. Sixty-two per cent of the dry crops area in Poodhai and fifty-four per cent in St. John's was affected by flooding and some wastage was recorded. Wastage was heaviest in peas, 38¢ per dollar harvested, next for water melon (due partly to flood water and partly to larceny) 35¢, next tomatoes 22¢, and corn 12¢. The average wastage was 24¢ per dollar harvested, and was far heavier in Poodhai, 53¢, than in St. John's, 17¢. This difference was not entirely due to bad drainage conditions in Poodhai, but also to the far higher proportion of peas grown in Poodhai (43%) than in St. John's (15%).

The characteristics of variable income, low expenditure and high wastage in dry season crops were probably related and form a vicious circle. Peasants were not willing to incur expenditure on these crops with the great uncertainty as to the final amount that would be harvested; on the other hand, crops could no doubt be far more assured by the employment of more labour at planting and harvesting. It seems most desirable that the drainage in these lagoons should be maintained in the best working order; only in this way can the peasants' confidence in dry season cultivations be obtained; and without such confidence the peasantry is losing a most remunerative source of cash income.

CONCLUSIONS

The survey of these two lagoons forms an interesting contrast with those in Bejucal and La Pastora. The farmers interviewed in Oropouche, (admittedly not the best in the whole lagoon area), were not so prosperous or progressive as in the other two areas. Their financial results were surprisingly poor considering that they had much land uncultivated, and undercultivated, and that they had ample family labour available. It was evident that most of them had done little planning to make more profitable use of their land and their time.

The causes of these poor results are not easy to define. The only major disability from which these Oropouche farmers suffered that was not found in other areas was the unsatisfactory drainage conditions on the lagoon land. This condition undoubtedly deterred farmers from spending money on labour for more intensive cultivation of dry season crops. On the other hand, the chief opportunity these farmers had missed was the cultivation of provisions on their uplands. With the supply of organic manure from their livestock close at hand, and the light texture of their soils, it should have been possible to plant provisions quite successfully after the rice planting, and reap them after the dry season planting; thus employing slack times, and augmenting the agricultural income.

It must be concluded that these farmers were not sufficiently enterprising to appreciate the short term commercial opportunities of their holdings. Lack of enterprise has no doubt been fostered by the income derived from cacao in the past; the peasant, in common with the larger cacao planter, is very averse to replacing cacao, even temporarily, by short term crops. Nevertheless, it would appear sound management for these peasants to have cut down some of their cacao, taken advantage of good demand for provisions and subsequently replanted new and improved cacao trees.

The unprogressive mentality is no doubt fostered also by the condition that these farmers were much more subsistence farmers as regards crops than those in the other two areas. The subsistence farmer is not so commercially minded as one who sells and buys more extensively; the subsistence farmer does not reckon his working time so closely, nor the income from his farm, little of which is cash, so accurately. This uncommercial mentality is undoubtedly much more widespread in Trinidad, and the West Indies generally, than recent surveys of peasant farming would indicate; the surveys at Bejucal and La Pastora both referred to areas close to Port-of-Spain and surveyors were constantly impressed with the shrewdness, commercial and agricultural acumen of the peasants. It does not follow, however, that peasants in more remote parts have equal business ability.

THE LOUISIANA SYSTEM OF SUGAR-CANE CULTIVATION *

BY
P. E. TURNER

INTRODUCTION

To understand the sequence of field operations, practised in the sugar-cane areas of Louisiana, some knowledge of the climate and soil conditions is needed.

Temperature

Louisiana is in the sub-tropics; the temperature at times falls below freezing point during the months November to February: the above-ground growth of the cane is killed by sharp frosts. For this reason it is necessary in the early spring to shave to ground level both the young plants and ratoons. By these means the dead and rotten cane is removed, and the way made clear for the growth of new, healthy shoots.

Under the tropical conditions which prevail in Trinidad there is no need for this operation: it would merely shorten the growth period of the crop and thus lead to loss in yield.

Rainfall

The annual rainfalls of the sugar-cane areas of both Louisiana and Trinidad average about 63 inches. In Louisiana the average monthly rainfalls during the period June to September range from 6 inches to 8 inches: the average monthly rainfalls for the remainder of the year range from 4 inches to 5 inches. In Trinidad the monthly rainfall from January to May averages 2¼ inches and during the remainder of the year 7½ inches. The rainfall in Louisiana is therefore more evenly distributed than in Trinidad. Louisiana has no well-defined dry season.

In Louisiana the crop is ripened by cold weather and is reaped during the period October to December. In Trinidad the crop is ripened by dry weather, and we aim to reap it during the period January to May.

In Trinidad the cultivation operations necessary for replanting are largely completed during the dry season while the crop is being reaped. In Louisiana these operations are not commenced until the winter is over, *i.e.*, some two or three months after the end of the crop season: the soil is then far from dry. Because we plough the soil when it is dry we can give it a better tilth than is given to the soil in Louisiana: we also destroy more weed growth before planting. In Louisiana more tillage and weeding operations are therefore required after planting than in Trinidad.

Soils

The sugar-cane soils of Louisiana range from light silty-loams to silty clays. On the average they are not as heavy as the Trinidad sugar-cane soils.

There is a water table in some of the lighter soils of Louisiana but it does not approach within a foot of the water-furrow bottoms. Sugar-cane is not planted on the top of the bed to cope with a high water-table, as it is sometimes suggested.

The heavier soils of Louisiana are capable of giving higher yields than the lighter soils: they give lower yields probably because of inadequate drainage.

Topography

The sugar-cane areas of Louisiana slope very gently away from the rivers to the swamps. The fall in level may be as little as 1 in 4,000. It is therefore very difficult to get the drainage water away. The flat sugar-cane areas of Trinidad have greater falls in level than this.

Trinidad's advantages and disadvantages

In general Trinidad has the advantage over Louisiana in that we have no winter frosts which kill the young plant and ratoon shoots and shorten the growth period of the crop; we have a well-defined dry season which enables us to give a good tilth to the soil, and to destroy a large proportion of our weeds by ploughing; and there is a greater fall in level on our flat lands which enables us to get drainage water away more easily. Louisiana has the advantage over Trinidad in that many of its soils are less heavy.

REGIONAL AND FIELD LAYOUTS

All mechanised field-operations in Louisiana are carried out with the use of high-clearance rubber-tyred tractors which straddle the beds. These tractors are less expensive to buy, have lower maintenance costs, and can work at higher speeds than the crawler tractors in use in Trinidad.

Consequently, in Louisiana, the regional and field layouts are of a type suited to the use of rubber-tyred tractors: there are few, if any, deep drains for the tractors to cross. It should be noted that drains 3 inches deep and 15 inches wide can bend the front axle of a rubber-tyred tractor, and damage the steering mechanism, when the tractor is driven at high

* Delivered in the form of a lecture at the I.C.T.A., 12th March, 1947.

FIG. II.

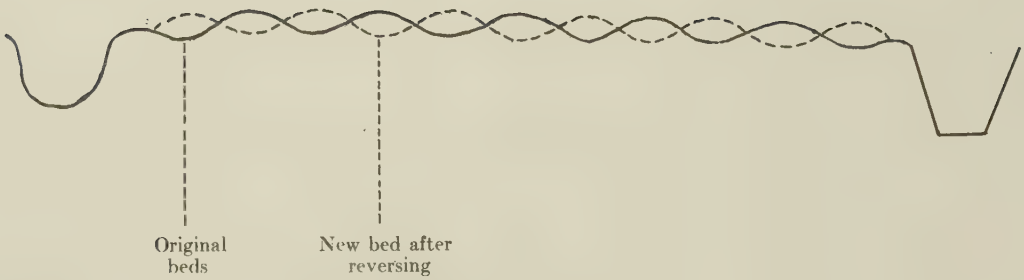
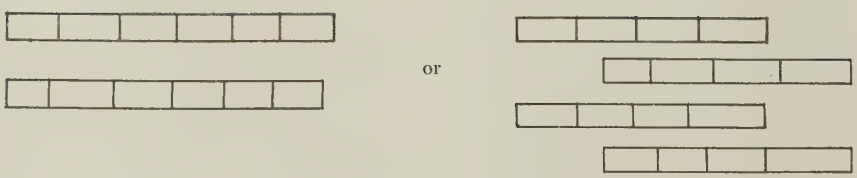


FIG III.

Method of Planting



beds and to make new beds with their centres over the old furrows (See Fig. II).

Fig. II makes evident the need for ditch banks.

Different procedures are used on different estates for reversing the beds. On some estates the cane stools are first destroyed with two gangs of four discs preceded by a middle-buster. On other estates this preliminary operation is omitted.

The beds may be reversed with a unit consisting of two 10-inch side ploughs (right and left hand) preceded by a 22-inch middle-buster and followed by a 14-inch middle-buster. 18-inch rolling coulters prepare the way for the side ploughs and rear middle-buster : a 22-inch rolling coulter prepares the way for the forward middle-buster. The forward middle-buster breaks down the top of the bed, the side ploughs transfer the soil to the old water-furrows, and the rear middle-buster begins the preparation of a new water-furrow at the centre of the old bed.

Alternatively the side ploughs and rear middle-buster may be replaced by two gangs of discs which are said to work the soil more thoroughly than the side ploughs.

Two operations are usually required with both types of unit to tear down the old beds and to form the new beds.

Ploughing

On some estates the soil is ploughed to the depth of a foot between the two operations.

The soil removed from the laterals, when they are dug and cleaned, is placed alongside these drains : in the course of time this makes the field dish-shaped. In consequence, water lies in the centre of the fields and the canes on the inner beds suffer from waterlogging, turn yellow, and give lower yields than those on the outer beds. As a remedy the quarter drains have to be deepened, sometimes to 6 inches, as they approach the laterals. The rubber-tyred tractors are liable to be damaged when crossing drains of this depth unless they are driven slowly and with care : the rate of work is thus slowed down.

These difficulties can be avoided by ploughing the fields in such a manner that they are given a slight camber. Ploughing takes place parallel to the lateral drains, progressing from the centre of the field outwards, the furrow slices being turned towards the centre of the field ; more than one ploughing, or "overlapping" ploughing, may be necessary to give the field a camber.

Conditioning the beds

When the new beds are first formed they are in rough condition and not raised to their full height. They are shaped, and their centres raised to at least 18 inches above the water-furrow bottoms, with disc gangs. Forward and rear sets of disc gangs may be used to condition a single bed, or the disc gangs may be used in tandem to condition two beds at a time.

Quarter drains

As soon as the new beds are formed it is essential to make the quarter drains. If heavy rain falls before the quarter drains are established, the water which collects in the water furrows cannot escape : the fields become flooded and the tilth which has been given to the soil is impaired or even destroyed.

Cover crops

The new beds are completed in the spring. Planting in cane is delayed until September (*i.e.*, until the last month before the crop season) as the above-ground growth of the young plants is in any case killed by the winter frosts. In the meantime use is made of the soil by growing a crop of corn, interplanted with soya beans, on the beds. A single-row grain-planter is used to plant the corn along the centres of the beds : the corn requires three or four disc-cultivations.

The corn stubble and the cover crop are ploughed into the beds with disc gangs in August and are allowed to rot for a month : they are considered to be a cheap form of nitrogen. Alternatively, they are buried by once more reversing the beds : in such cases the beds are remade in their former positions.

Cane would be planted as soon as possible after the first rains under the conditions which obtain in Trinidad. Delay in planting, to grow a cover crop, would lead to loss in yield of cane. It would also be necessary to plough the cover crop into wet soil : this would have a disastrous effect on the tilth of our soils.

Planting

In Louisiana the planting furrows are made in September with shallow middle-buster ploughs : disc gangs are used in the same operation to improve the soil tilth, to pull back soil which has been washed into the water furrows by rain, and to weed the beds.

Entire canes are planted by hand in the furrows, without removing the leaves from the stalks. Two or more canes are placed either side by side, or overlapping (See Fig. III).

Two to four short tons of cane are used to the acre for planting. This large amount of cane is necessary because many of the eyes become diseased and die during the winter months which follow planting.

The cane is immediately covered to a depth of 3 inches on the heavier soils, and 5 inches on

the lighter soils, with disc-gangs. Four disc-gangs can be used on a single bed—four discs in each of the two forward gangs which penetrate the soil to a depth of 9 inches, and five discs in each of the two rear gangs which penetrate the soil to a depth of 6 to 7 inches. Alternatively the disc gangs may be arranged to work two beds at the same time.

The cane is more deeply covered on lighter than heavier soils because the discs throw up more earth on the former than the latter. The soil above the cane is sometimes consolidated with a roller which is drawn over the top of the bed.

A cover crop, of a type which does not smother the young plant cane, may be planted along the centre of the beds with the cane. The cover crop is killed by the winter frosts, and is incorporated in the soil when the beds are "boxed".

Cultivating and Weeding

Soil is continuously washed from the beds into the water furrows by rain. The beds and water furrows are maintained, and kept as free from weeds as possible, with disc gangs.

When reaping begins in October all cultivation operations cease, and the young plant cane is left to fend for itself until the spring.

Spring cultivation of young plants and ratoons

Frosts during the winter kill all above-ground growth of plant and ratoon cane. When cultivation operations are resumed in the spring, both crops receive identical cultivation treatments.

Stubble shaving

Revolving circular discs or "stubble shavers" are used to cut down both the young plants and ratoons to surface level: in this way all dead growth is removed: only the stools remain. It has been mentioned that this operation is unnecessary under Trinidad conditions and would result in lower yields.

Boxing

Stubble shaving is immediately followed by "barring off" the sides of the plant and ratoon beds: this operation is known as "boxing". The bed is cut to a width of 14 inches and the soil is thrown into the water furrows. The operation is usually performed in two stages with right and left hand 10-inch side ploughs, preceded by rolling coulters * The cane stools are thus left in a narrow box, the sides of which are exposed to the sun: by these means the soil around the stool is warmed. The soil in the box is loosened, and weeds are removed, with the use of hand implements.

The beds are restored to their original form after a month. Two cultivations are required to bring this about. Single-row or two-row disc gangs may be used. With two-row disc gangs it is necessary to have a guide attachment for the first cultivation: there are no furrows to serve as guides for they have been destroyed by boxing. Fertiliser is applied by means of hoppers attached in front of the disc gangs: the fertiliser is deposited at the side of the box and covered with soil by the discs. The second cultivation is performed with the same tools: there is now no need for a guide attachment to the two-row cultivator.

Under Trinidad conditions it is unlikely that the operation of boxing can be safely performed on young plants which may have grown to a height of 10 feet, or more, by the beginning of the dry season. Boxing would damage the roots of the young plants which would probably dry out and die. It might be of value to ratoons, if it is undertaken shortly after reaping and the beds quickly restored to their original form: this would be a matter for experiment. The operation restores the tilth to the sides of the beds, and should result in larger ratoon yields and longer ratooning if it is successful.

Subsequent cultivations

Subsequent plant and ratoon cultivations with disc gangs are necessary to maintain the beds, which are continuously eroded by rain, to keep the water furrows open, and to control weed growth. If the weather permits they are repeated, as often as required, until the cane is liable to damage by the tractors which straddle the beds. The early cultivations should be as deep as possible: when the root system has spread they should be shallow. Mechanical cultivation ceases when tractors can no longer be used without damaging the cane.

Weeding along the rows of cane, in the centre of the beds, is performed by hand: flame-weeders are under trial but have been found to damage the cane. Flame-weeders have been found very useful, however, in controlling weed growth on the ditch bank where no cane is grown.

MECHANICAL HARVESTING

The yield of sugar-cane in Louisiana averages about 20 short tons to the acre. A few estates, *e.g.*, some of those which camber their fields before making new beds, approach 30 tons. Two ratoon crops are reaped as a rule.

Mechanical harvesting is possible because the canes are upright and of relatively even height at the time of reaping. Occasionally tall cane lodges after heavy rain followed by high winds: the heavy rain softens the beds: the

* This unit is similar to that employed for reversing the beds, with the middle-busters and their rolling coulters removed.

high winds uproot the cane. In such cases it is necessary to harvest the cane by hand.

Types of mechanical harvester

There are three types of harvester in use in Louisiana, the Thornton, the Thomson and the Wurtele : all three are mounted on rubber-tyred tractors : each cuts and tops the cane with revolving discs. The Thornton has a conveyor which can deposit up to eight rows of cane across a single water-furrow after reaping. The Thomson can deposit up to six rows of cane across a single water-furrow. The Wurtele loads the cane as it is reaped. None of these machines can be used successfully on slopes.

The Thornton harvester is the lightest of the three machines. It has the great advantage of being a four-wheeler : also the reaping mechanism and the conveyor can be detached from the tractor, when they are not required, and the tractor used for cultivation operations. None of the beds needs to be cut by hand before the Thornton is put into the field.

The Thomson harvester is a three-wheeler, one of the front wheels being removed to accommodate the reaping mechanism. It is heavier than the Thornton and cannot be removed from the tractor. It is necessary to reap one bed in each field by hand before the Thomson can be used.

The Wurtele harvester is also a three-wheeler. Three beds of cane have to be cut by hand before the Wurtele can operate. In addition to reaping, the Wurtele trashes the cane and loads it in carts drawn alongside the harvester. The Wurtele can also chop up the tops with an ensilage cutter and blow them into a cart which is drawn in front of the harvester. It is the heaviest of the three harvesting machines.

Quality of work

It is rare in Louisiana to see cane flush with the soil surface by the mechanical harvesters : it is not uncommon to see it cut six inches above ground level. It appears that the reaping mechanism is subject to damage if the cane is cut at soil level.

Although the topping mechanism of the harvesters is continuously variable with respect to height, it cannot be adjusted quickly enough to top individual canes at the proper point : average cutting is the best that can be obtained. Consequently, much of the cane is cut too high, and much too low.

Nevertheless the use of mechanical harvesters is justified under Louisiana conditions, not only because of the high wages paid to labour, but also because of the speed at which the cane can be reaped. Rapid harvesting of cane is essential if the temperature drops to 28° F. for inversion of the juice then commences.

Use of harvesters in Trinidad

Even if it is found worthwhile to introduce the Louisiana field-layout to the flat areas of Trinidad, the use of harvesting machines is likely to be limited. The Thornton, Thomson and Wurtele harvesters do not lend themselves to the reaping of recumbent cane, nor does it seem possible to adapt them to reap recumbent cane. It is likely that their use in Trinidad would be confined to the reaping of crop plants and old ratoons : even then it would be essential for the canes to be of relatively even height.

Burning of cane

The cane can be burnt before harvesting in Louisiana only if there has been a frost. If there has not been a frost it is burnt two days after harvesting, provided there has been no rain. If rain follows harvesting it cannot be burnt and is delivered to the factory with its trash.

MECHANICAL LOADING

The cane which has been placed across the water furrows, by the Thornton and Thomson harvesters, is loaded into carts by portable grabs which are drawn by mules or rubber-tyred tractors. Using a tractor-drawn loader the canes are pushed into a bunch by a two-fingered blade which precedes the tractor : when the bunch is large enough the grab is lowered and the bunch is transferred to a rubber-tyred cart which is drawn alongside. No need arises to collect the canes into bunches by hand.

CONCLUSION

There is one question that will be asked. Is it likely that heavy yields of cane will be obtained in Trinidad with the Louisiana layout as with existing systems of cultivation at present ? It is impossible to answer this question without experiment. We do not know what yields would be obtained in Louisiana if the growth period of the crop were not shortened by frost damage. In Trinidad we are now commonly obtaining, through improvements in our cultivation methods, plant-cane yields of 50 tons to the acre ; 60-ton yields are not uncommon ; 70-ton and even 80-ton yields are occasionally obtained : would eroded six-foot beds — the beds in Louisiana are badly eroded by rain — support such heavy yields. On the other hand our ratoon yields are not yet as large as we should like them to be — they might be greatly increased by the operation of boxing. Only by field experiments can we decide the worth of the Louisiana system under Trinidad conditions.

A PRELIMINARY INVESTIGATION INTO NITRIFICATION IN BRITISH GUIANA SUGAR-CANE SOILS

BY

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Introductory

In discussing the results obtained in a field and laboratory investigation of some representative sugar-cane soil-profiles in British Guiana carried out by members of the staff of the Chemistry Department of the College on materials collected at sites selected by Mr. R. R. Follett-Smith, † the suggestion was advanced that, under the flood-fallow system practised in many British Guiana sugar estates, the nitrogen-nutrition of the sugar-cane, growing in highly acid, badly aerated, reducing soils is probably ammoniacal rather than nitric, because, under reducing conditions, nitrification cannot occur, being essentially an oxidising process. The failure of lime to act beneficially, (which is a common experience in British Guiana sugar-cane fields) may be explained on this supposition by assuming that the soil environment is not suitable for the maintenance or development of a nitrifying micro-organic flora which is known to require specific conditions of aeration, moisture, temperature and soil reaction.

Thus it has been shown that, whereas ammonification (brought about mainly by certain fungi) can proceed over the wide reaction range pH 3.7 to 9.0, the first stage of nitrification, namely, ammonium to nitrite, (controlled chiefly by *Nitrosomonas* and *Nitrococcus*), can proceed rapidly only over the very much narrower range, pH 7.0 to 7.8. The second (oxidative) stage of nitrification, namely, nitrite to nitrate (controlled mainly by *Nitrobacter*) can occur, however, over the wide reaction range pH 3.9 to 8.0, but it can only affect nitrite.

Under natural circumstances, in agricultural soil is capable of nitrification, certain well-known 8.0, the rapidity of nitrification is generally determined by the rate of ammonification. At the extreme acid end of the range, however, the rate of formation of nitrate may be restricted by the rate of formation of nitrite, since this stage is really rapid only when the reaction approximates to neutrality. The accumulation of nitrite that may thus be appreciable in highly acid, badly aerated or reducing soils, is frequently very harmful since nitrite is highly toxic to most plants. Consequently, nitrite may be abundant in many of the British Guiana highly acid sugar-cane soils, although its presence (as far as the writers are aware) has not yet been demonstrated.

In highly acid soil which is rendered alkaline by the addition of calcium carbonate, rapid nitrification should normally ensue unless the micro-organisms that control nitrification are completely absent, in which case it may be necessary to add an inoculum taken from an alkaline-reacting fertile soil, although wind-borne dust may serve the same purpose if it originates in a fertile land area.

In order to ascertain whether or not a given soils whose reaction lies between pH 4.0 and pH tests may be applied under controlled laboratory conditions. ‡ These have accordingly been used to determine the degree of nitrification attained by composite A-horizon surface samples of the British Guiana soils collected during the profile investigations above mentioned.

Experimental

The general features of the soils examined are shown by the routine laboratory data in Table I.

Disscussion of the Laboratory Data :

Each of the soils is very highly *acid* (pH 5.3 or less). *Organic matter* and *nitrogen* contents are fairly high to medium on Trinidad standards, except the sample of true pegasse (No. IX; Wales (1)), which has an exceptionally high organic content. The Riverside Silt soils contain least organic matter and nitrogen. Carbon-nitrogen ratios are variable but tend generally to be low (less than about 11) in soils other than Pegassy Clay. This denotes either considerable surface erosion, or organic wastage, or profound biological breakdown of the organic component and a paucity of fresh plant residues (trash). None of the soils is salty except the first two Port Mourant soils (Nos. III and IV) which, however, contain only small and probably harmless amounts of salts (conductivity values not here recorded).

Available phosphate is relatively very low for all except two of the soils, of which one (No. I, Diamond (1) is near the border-line of phosphate adequacy and the other (No. II Diamond (2)), which is very rich in available phosphate, had probably been recently manured with filter-press mud.

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* Diploma Student : Acting Junior Analyst.

† Some Sugar-Cane Soil Profiles of British Guiana. F. Hardy and G. Rodrigues, *Proc. 1946 Meeting of Sugar Technologists, B.W.I.S.A. (Inc.),* September, 1946.

‡ " Principles of Soil Microbiology ", S. A. Waksman.

Table I:

Laboratory Data for the Soils Examined by Nitrification Tests

Soil-Sample	Sand content %	Index of Texture (I.T.)	Reaction Normal pH	Org. matter content %	Total nitrogen content %	C/N ratio	Avail. P_2O_5 p.p.m. *	Avail. K_2O p.p.m. *	Lime requirement t./ac. 6 ins.
(A) FRONTLAND CLAY									
(III) Pt. Mourant (1)	9	42	5.1	3.8	0.21	10.4	*13*	*170*	3.9
(IV) Pt. Mourant (2)	7	46	5.0	5.3	0.26	11.9	*22*	*156*	4.6
(V) Pt. Mourant (3)	7	40	5.0	3.5	0.21	10.0	*19*	*176*	3.4
(VI) Pt. Mourant (4)	6	42	5.2	3.2	0.19	10.0	*8*	*291*	2.5
(B) PEGASSY CLAY									
(II) Diamond (2)	10	53	4.5	6.8	0.21	18.5	(384)	216	13.6
(VII) Blairmont (1)	8	45	4.9	5.5	0.27	11.9	*9*	*171*	6.1
(IX) Wales (1)	—	(72)	4.3	85.3	1.11	44.6	*12*	*127*	15.0
(C) RIVERSIDE SILT									
(I) Diamond (1)	7	50	4.7	3.1	0.17	10.7	46	*134*	7.5
(VIII) Blairmont (2)	25	22	5.3	3.0	0.11	†(16.5)	*28*	*110*	1.5
(X) Wales (2)	5	42	4.5	3.1	0.18	10.2	*14*	*101*	6.9

* Values denoting possible inadequacy are *italicized*.
† Contains considerable amounts of charcoal and cane-trash.

Available potash is generally low, that is, less than the value provisionally accepted as the limit of adequacy for heavy sugar-cane soils (200 p.p.m.). The Riverside Silt soils show greatest potash deficiency.

Lime requirement: This was determined by the Hardy-Lewis electrometric titration method. * The values obtained are expressed in Table I as tons of calcium carbonate required theoretically to raise the reaction of one acre of surface soil, 6 inches deep, to pH 7.2. They range in magnitude from 1.5 to 15 tons per acre and tend to be highest for Pegassy Clay.

Nitrification tests: The following tests were applied to each of the composite soil samples.

(1) *Natural nitrification:* Fifty grams (50 g.) of the air-dry soil are weighed out and slowly moistened to about half-saturation (two-thirds of sticky-point moisture value) without destroying the natural structure. The soil is then put into a tared beaker and stored for 30 days in a cool dark cupboard. It is maintained at this optimum moisture content by weighing every third day and adding water if necessary to bring to the correct weight. Nitrate is determined at the end of the incubation period by the standard disulphonic acid colourimetric method.

(2) *Nitrification after liming:* Fifty grams (50 g.) of air-dry soil are intimately mixed with 0.22 g. of finely-divided calcium carbonate and then moistened and stored as before. Nitrate is determined in the same way.

NOTE: The amount of lime used is equivalent to about 4.0 tons per acre 6 inches of air-dry soil, which, according to the laboratory values for lime requirement, is not quite sufficient to neutralise the acidity of the majority of the soil samples examined.

(3) *Nitrification of added ammonium salt:* Fifty grams (50 g.) of air-dry soil are moistened as in (1) and 5 cc. of a solution of ammonium sulphate, containing 30 mg. of nitrogen, are added. The moist soil is stored as before, and nitrate determined at the end.

NOTE: The amount of ammonium sulphate added is equivalent to about 60 cwt. per acre which is a very large dosage according to manurial practice.

(4) *Nitrification of added ammonium salt after liming:* This is carried out exactly as in the last two procedures combined.

NOTE: The standard amount of calcium carbonate used (namely, 0.22 g. per 50 g. of soil), in theory, is just sufficient to neutralise the ammonium sulphate added (0.03 g. N, equals 0.15 g. ammonium sulphate). It leaves no surplus for neutralising natural soil acidity.

Results of nitrification tests: The results obtained with the British Guiana A-horizon composite soil samples are given in Table II.

Discussion of results: None of the values for nitrate-nitrogen recorded in Table II could

* *Journ. Agric. Sci.*, 1929, XIX, p. 17.

Table II :

Results of Laboratory Nitrification Tests

(The values are parts of nitrate-nitrogen per million of air-dry soil)

	Method 1	Method 2	Method 3	Method 4
	Natural nitrification (control)	Nitrification after liming ($CaCO_3$ added)	Nitrification of ammonium $(NH4)_2$ SO4 added)	Nitrification of ammonium ($CaCO_3$ and $(NH4)_2$ SO4 added)
(A) FRONTLAND CLAY				
(III) Pt. Mourant (1)	13.5	3.7	4.1	5.6
(IV) Pt. Mourant (2)	8.6	5.6	7.4	9.0
(V) Pt. Mourant (3)	23.1	21.6	16.6	18.0
(VI) Pt. Mourant (4)	4.9	3.2	3.6	2.8
(B) PEGASSY CLAY				
(II) Diamond (2)	17.4	16.8	11.2	18.2
(VII) Blairmont (1)	10.5	10.5	5.7	11.0
(IX) Wales (1)	24.7	24.0	9.0	22.6
(C) RIVERSIDE SILT				
(I) Diamond (1)	5.6	6.3	3.2	6.7
(VIII) Blairmont (2)	5.5	3.5	5.2	23.6
(X) Wales (2)	7.4	8.2	3.9	5.0

be regarded as more than medium in amount (high values would be 50 p.p.m. or more).

(1) The natural nitrate-producing capacity is greatest (though still only medium-high) in samples No. V (Port Mourant (3)) and No. IX (Wales (1)), both of which had been recently flood-fallowed. It is distinctly higher for the two flood-fallowed Frontland Clay soils than for the corresponding unflooded soils.

(2) Liming has scarcely affected the nitrifying capacity of any of the soils; the general effect is slightly to depress the formation of nitrate. The amount of lime used, however, was inadequate for completely neutralising soil acidity.

(3) Added ammonium salt has not been nitrified at all; the general effect again was depressing.

(4) Ammonium salt added to the limed soil has also scarcely been nitrified, although nitrate production tends to be very slightly higher in the presence of lime. The amount of lime used was quite inadequate for correcting the very high degree of acidity which these soils naturally possess.

Conclusions

Although the soil samples had been stored in an air-dry condition for several weeks before the tests were applied, it is thought that the drying could not have been responsible for their low nitrifying capacity, since it is known that simple air-drying does not usually destroy the organisms of nitrification which, if present, quickly multiply when the environmental conditions suit them. It is concluded rather that the right sort of micro-organic flora is absent from these soils, and that failure to nitrify when their reaction values had been raised and their calcium status somewhat improved by liming may be attributed to the absence of the requisite nitrifying organisms.

The effect of adding an inoculum from a highly-nitrifying soil was not determined and this was a serious omission which should be rectified in future laboratory studies of British Guiana sugar-cane soils.

It is possible that the marked shortage of phosphate which characterises these soils may partly account for their low nitrifying capacity, because soil micro-organisms need an abundant supply of soluble phosphate for satisfactory growth and multiplication. The scarcity of phosphate is not thought to be the chief or critical factor, however, since one of the soils (No. II, Diamond (2)), although it contains a very high amount of available phosphate (384 p.p.m.), yet showed only a slightly (though distinctly) higher nitrifying capacity than most of (but not all) the other soils.

Recommendation

The whole investigation should be repeated with soil samples taken freshly from the field. Care should be taken to add enough lime in experiments (3) and (4) completely to neutralise the soil acids as well as to provide a sufficient excess of base to neutralise the acidity generated by the nitrification of the added ammonium sulphate. Finally, a suitable amount of soluble phosphate should be added to provide for the needs of the nitrifying organisms.

EFFECT OF TROPICAL KUDZU ON YIELD AND COMPOSITION OF FORAGE GRASSES

BY

ARNAUD J. LOUSTALOT AND CARLOS CERNUDA *

There is a definite need for a high protein legume for forage in Puerto Rico. Protein concentrates are imported into the island in large quantities and they constitute the most expensive part of the livestock ration. Until recently there has been no legume introduced into Puerto Rico which would grow and produce satisfactorily under tropical conditions.

In 1940 the United States Soil Conservation Service in Puerto Rico introduced a species of *Pueraria* known as *P. phaseoloides* (Roxb.) Benth. *(P. javanica Benth.)* now commonly known as "tropical kudzu." (1) Ths legume appears to have the outstanding qualities of its close relative *P. thunbergiana* (Sieb. and Zucc.) Benth. in the southern United States and is superior in some respects in that it seeds heavily, is readily established from seed, and grows vigorously under Puerto Rican conditions.

In the Temperate Zone it has been found that livestock forage consisting of a legume-grass mixture is more economical and profitable than a forage of grasses alone. The exceptional value of legumes is due to the fact that they are rich in protein, certain vitamins, calcium, and other essential minerals. Since legumes have the ability to accumulate nitrogen from the air through nodule-forming bacteria in the roots, they do not have to be fertilized with commercial nitrogen fertilizers. This element is most frequently lacking in tropical soils and is the one from which proteins are synthesized.

To obtain quantitative information as to the effect of tropical kudzu on the yield and composition of some of the forage grasses of Puerto Rico, the following experiment was performed.

EXPERIMENTAL

In May 1946 plots 15 feet by 30 feet of "gramalote" *(Panicum maximum Jacq.)*, Napier *(Pennisetum purpureum* Schum.), Napier-Millet hybrid, and "malojillo" grass *(Panicum purpurascena* Raddi.) were planted alone and in combination with tropical kudzu. (2) The Napier-Millet hybrid and Napier grasses were planted from stem cuttings but the "gramalote" and "malojillo" grasses were planted from crown divisions.

Table 1

Yield per acre at first harvest of grasses grown alone and with tropical kudzu, September 13, 1946

Grass	Yield		Tropical kudzu in mixture (Dry basis)	Dry matter in tropical kudzu	Dry matter in grass	Dry matter in mixture
	Fresh weight per acre	Dry weight per acre				
	Pounds	*Pounds*	*Percent*	*Percent*	*Percent*	*Percent*
Napier-Millet Hybrid	50,290	24,249	——	——	40.90	——
Napier-Millet hybrid Tropical kudzu	61,105	16,961	28.0	24.05	29.53	27.76
"Gramalote"	43,560	11,878	——	——	27.27	——
"Gramalote" Tropical kudzu	44,770	9,997	48.3	20.56	24.28	22.33
Napier	41,140	10,926	——	——	26.56	——
Napier Tropical kudzu	55,660	14,994	55.6	26.78	27.18	26.94
"Malojillo"	16,940	3,567	——	——	21.06	——
"Malojillo" Tropical kudzu	41,140	7,808	63.7	17.76	21.57	18.98

* Chemist of the Federal Experiment Station in Puerto Rico and collaborating chemist in cooperation with the Government of Puerto Rico, respectively.

(1) Telford, E. A., and Childers, N. F. Tropical kudzu in Puerto Rico. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 27. 1947.

(2) Plantings made by E. A. Telford, Soil Conservation Service.

In the plots where the grasses were grown alone, the stem cuttings and crown divisions were planted in rows three feet apart with one foot between plants. This was the equivalent of 14,500 plants per acre. In plots where the grasses and the kudzu were grown together, every other row was planted to the grass with the equivalent of approximately 7,250 grass plants per acre. The tropical kudzu was planted from seed in all the grass-kudzu plots at the rate of three pounds of seed per acre, planted in alternate rows with the grasses.

The plots were located on relatively fertile bottom land. In October, 5 months after planting, the plots were harvested and data on relative yield and composition of the various grass and tropical kudzu plots were obtained. These are presented in Tables 1, 2, and 3. Rainfall was plentiful during the experimental period and all plots appeared to have made satisfactory growth. However, it was clearly evident to the eye that the plots in which the tropical kudzu and grass were growing together were greener and more vigorous than those of the grass alone.

To obtain the approximate yield per acre, duplicate samples, each cut from an area 4 yards square were harvested from representative sections of each plot. The average yield from the two squares was multiplied by the appropriate factor to obtain the yield per acre. These samples were chopped into small pieces and 20-pound samples were taken for dry-weight determinations and chemical analysis. After the samples were obtained, the entire plots were cut and the forage removed. The grass and tropical kudzu were then allowed to grow again so that data on subsequent yield and composition could be obtained.

It is evident from the data in Table 1 that the yield of fresh forage material is greater in all plots where tropical kudzu was grown with the four different grasses. However, on a dry-weight basis, the yield of the grass-kudzu plots was less with Napier-Millet and "gramalote" but Napier and "malojillo" yielded more dry matter when grown with tropical kudzu than when grown alone. One reason for this may be the fact that the amount of tropical kudzu in the latter two plots was more than in the Napier-Millet and "gramalote" mixtures. Since the yields per acre were calculated from relatively small samples, the actual figures may not be strictly accurate. They do give, on the other hand, some idea as to what may be expected and show the relative differences in yield between the various grass and grass-kudzu plots.

It is of interest to note (Table 1) the effect of kudzu on the percentage dry weight of the Napier-Millet grass. Growing alone, the percentage dry matter of this grass was over 40, but when grown with tropical kudzu the percentage dry matter in the grass was reduced to 29.53 and thus was considerably more succulent and probably more palatable to livestock. There was a similar but smaller effect of tropical kudzu on the dry matter content of "gramalote" grass. The dry matter content of Napier or "malojillo" grass was not appreciably affected when grown with tropical kudzu.

The data presented in Table 2 show that when tropical kudzu was grown with the four grasses, the quantity of calcium, magnesium, and potassium in the grass-kudzu mixture was

Table 2

Mineral composition (1) of grasses with and without tropical kudzu

Experimental Plots	Ash	Calcium	Magnesium	Potassium	Phosphorus
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Napier-Millet hybrid	11.02	0.23	0.33	1.22	0.34
Napier Millet Tropical kudzu	9.98	.37	.39	1.70	.44
"Gramalote"	10.01	.21	.37	1.58	.24
"Gramalote" Tropical kudzu	10.94	.96	.65	2.49	.33
Napier	12.51	.25	.34	1.69	.39
Napier Tropical kudzu	8.64	.78	.53	1.87	.30
"Malojillo"	9.59	.17	.13	1.53	.38
"Malojillo" Tropical kudzu	7.05	.69	.44	1.74	.23

(1) Expressed as percentage of dry weight.

markedly increased over that of the grasses grown alone. The amount of phosphorus was increased in the case of the Napier-Millet-kudzu combination and in "gramalote"-kudzu mixture, but in the Napier or "malojillo"-kudzu mixture the phosphorus was somewhat reduced.

From the data in Table 3 it is evident that nitrogen and protein content of the mixture consistently increased in all cases where kudzu was grown with the grasses. In the Napier-Millet-kudzu combination the increase was relatively small but in the three other grasses the nitrogen and protein content of the kudzu-grass mixture was 2 to 3 times as great as in the grasses grown alone. The "gramalote"-kudzu mixture contained more ethersoluble extract and less crude fiber than the "gramalote" alone. However, in the three other grass-kudzu mixtures the reverse was true.

On January 23, 1947, approximately 3 months after the first cutting the plots were harvested again. The growth during this period was fairly good in all plots but the yields in general were much lower than in the first cuttings, mainly because of the shorter growing period and the low rainfall. The amount of kudzu was markedly reduced in all plots and practically eliminated in the Napier-Millet hybrid and "gramalote"-kudzu plots. This was due to the fact that the kudzu was cut close to ground level at the first harvest and consequently it was smothered by the vigorous new growth of the grasses, particularly in the "gramalote" and the Napier-Millet hybrid plots. (1) In spite of this, the beneficial effect of the kudzu was evident by the higher yields of forage in the mixed plots. In all plots where kudzu had grown or was growing with the grasses, the yields were significantly increased. Likewise, the nitrogen and protein content was significantly higher in the grass forage from the kudzu grass plots than in the forage from grass plots alone. The data are presented in Table 4.

It is apparent from this preliminary experiment that the yield and nutritive value of some grasses such as "malojillo" and Napier and "gramalote" may be increased by planting tropical kudzu with them. Feeding this enriched forage mixture to livestock should reduce the need for expensive imported concentrates and may also increase milk and meat production.

SUMMARY

1. Napier, Napier-Millet hybrid, "gramalote", and "malojillo" grass were grown alone and in combination with tropical kudzu.

2. At the first harvest, 5 months after planting, the yield of fresh forage was greater in all plots where kudzu was grown with the grasses than in plots where the grasses were grown alone. However, on a dry-matter basis the yields were higher only in the plots where kudzu was grown with Napier or "malojillo" grass.

3. The amounts of calcium, magnesium, and potassium in the grass-kudzu forage were considerably higher than those in the grasses alone. The amount of phosphorus was increased only in the Napier-Millet-Kudzu and in the "gramalote"-kudzu mixtures.

Table 3

Nitrogen, protein, ether-soluble, and crude fiber content of grasses planted with and without tropical kudzu

Experimental Plots	Nitrogen	Crude protein (N x 6.25)	Ether-soluble extract	Crude fiber
	Percent	*Percent*	*Percent*	*Percent*
Napier-Millet hybrid	0.53	3.29	1.95	35.4
Napier-Millet hybrid tropical kudzu	.86	5.38	1.77	38.8
"Gramalote"	.69	4.32	1.38	36.9
"Gramalote" Tropical kudzu	2.04	12.75	1.92	35.7
Napier	1.20	7.50	1.65	30.5
Napier Tropical kudzu	1.83	11.42	1.53	41.4
"Malojillo"	.94	5.87	3.35	29.3
"Malojillo" Tropical kudzu	2.00	12.90	2.32	40.7

(1) Tropical kudzu cut at 6 to 8 inches above ground usually gives a good comeback, provided rainfall is plentiful.

4. The nitrogen and protein content of the kudzu-grass forage was 2 to 3 times higher than in the grasses alone.

5. At the second harvest, 3 months after the initial cutting, the yields of grass-kudzu plots, either on a fresh or dry basis, were higher than in the grass plots alone. Likewise, the protein content of the grass-kudzu plots was higher than that of the grass plots alone.

6. The results, although of a preliminary nature, indicate that the yield and nutritive value of some forage grasses may be increased by planting tropical kudzu with them. Feeding this enriched forage to livestock should reduce the need for expensive imported concentrates and may also increase milk and meat production.

Table 4

Yield per acre and protein content at second harvest of grasses grown alone and with tropical kudzu, January 23, 1947

Experimental plots	Yield		Tropical kudzu in mixture (dry basis)	Nitrogen	Crude protein (N x 6.25)
	Fresh weight per acre	Dry weight per acre			
	Pounds	*Pounds*	*Percent*	*Percent*	*Percent*
Napier-Millet hybrid	24,805	7,595	——	0.68	4.25
Napier-Millet hybrid and Tropical kudzu	26,620	8,885	0	.71	4.44
"Gramalote"	13,310	3,708	——	.68	4.25
"Gramalote" and Tropical kudzu	16,940	4,864	4	.81	5.06
Napier (Merker)	33,275	8,355	——	.49	3.06
Napier Tropical kudzu	35,090	(1)	19	1.40	8.75
"Malojillo"	9,680	(1)	——	.53	3.31
"Malojillo" Tropical kudzu	12,100	(1)	24	1.60	10.00

(1) The dry-weight data of these plots were lost as the result of an accident.

REVIEW:

A Catalogue of Insecticides and Fungicides, by Donald H. Frear, Ph.D. Vol. 1. Chemical Insecticides. *Published by the Chronica Botanica Co., Waltham, Mass., U.S.A. and Wm. Dawson & Sons Ltd., London, W.C. 2, England. Price: $6.50.*

A comprehensive list of insecticides with data compiled from various sources. By an ingenious coding system compounds with similar chemical constitution may be easily found in the text. A lengthy list of references is given, and index numbers with each chemical enable the title of the original paper dealing with it to be determined. Brief notes as to toxicity to individual insect species are given with each compound, and a list is also given of patents pertaining to insecticides. A book of reference of obvious value to chemists working in the insecticide field.

F.J.S.

FIELD TESTS WITH DDT AGAINST INSECT PESTS OF FOOD-CROPS IN THE LESSER ANTILLES

By R. G. FENNAH

(Entomologist, Food-crop Pests Investigation, Windward and Leeward Islands)

INTRODUCTION

In an earlier paper (Fennah, 1945) it was stated that field trials of DDT against pests of food-crops had been initiated in the Lesser Antilles. The following is an account of this work, which was carried out between September, 1945 and March, 1946 at Cades Bay Settlement and Yepton's Estate, Antigua, B.W.I.

MATERIALS AND COST

DDT was applied either as a 10 per cent. dust mixed with cryolite, or in aqueous dilutions of a stock emulsion comprising by weight DDT 15%; tetralin (tetrahydronaphthalene) 26%; Triton B-1956 (a phthalic glyceryl alkyd resin) 4%; hard soap 0.4%; water 54.6%. The dust was applied by beating from a coarse cotton bag, and the emulsion by means of a hand sprayer of the atomising type (Hudson continuous sprayer), or with a knapsack sprayer (Myer's "Kwikfill"), methods all suitable for peasants. Where the number of plants to be sprayed is small, as in a garden plot, a hand sprayer of the type suggested is advantageous in that, owing to the high degree of dispersion of the spray, the sprayer can be used very close to the plant without sacrificing evenness of spray deposit. Such use at close quarters gives an efficient cover and greatly reduces wastage from spray missing its objective.

The cost per gallon of the above emulsion, at current prices, is rather less than 8/- (customs duty free). This estimate allows a small margin to cover the cost of adding extra soap to stabilise the emulsion in districts where the water is hard. The cost of application is more variable as it includes the cost of transporting water for diluting the emulsion as well as that of the actual spraying. In the circumstances which prevailed in one of the areas where trials were carried out it was found that all the requisite operations for the spraying of a two-acre plot were completed, from storeroom back to storeroom, by two men in 1½ to 2 hours. The cost of application per acre on this basis was approximately a shilling. Frequently one operator is sufficient.

The cost per plant varies with the number of plants per acre and the quantity of spray applied. It is possible to keep cost of material at a minimum by accurate and intelligent spraying, as wastage of material is avoided. The time taken per acre in the case cited above was largely spent in giving careful attention to individual plants of relatively high market value.

Wastage was estimated by comparing deposits left on microscope slides placed on the ground between plants and between rows with a deposit of known weight. When dust was employed the slides were lightly smeared with glycerine and were placed between rows and at different distances to leeward of the plot. The ineffective portion of spray as so measured was lowest in the case of large cabbages and densely-growing tomatoes and beet (less than 5%), and highest in that of onions and newly transplanted seedlings (40—60%). As both onions and seedlings required a very small volume of spray the actual amount of spray wasted per acre was slight, notwithstanding the relatively greater inefficiency of the application.

RESULTS OF INSECTICIDAL TRIALS

The insect pests against which trials of DDT were carried out fell into two groups: (1) those living on the leaf surface and feeding (a) by chewing—Cabbage butterfly (*Ascia monuste* (L.)), Diamond-back moth (*Plutella maculipennis* Curt.), Beet webworm, (*Zinckenia fascialis* Cram.) and *Anticarsia gemmatalis* Hubn. or (b) by sucking—Green bug (*Nezara viridula* (L.)), eggplant lace-bug (*Corythaica planaris* Uhl.), Hay-grass bug (*Solubea pugnax* (F.)), aphids (*Aphis gossypii* Glov. and *Toxoptera aurantii* Boyer) onion thrips (*Thrips tabaci* Lind.), and (2) those living in partial concealment—cotton bollworm (*Heliothis armigera* Hubn.) on corn-cobs, the leaf-mining flies *Agromyza* sp. near *flaveola* Fall. on onions and *Liriomyza pusilla* Meig. on onions and cabbage.

DDT v. *Ascia monuste* (L.) and *Plutella maculipennis* Curt on cabbage

Date of Planting: 5/11/45
Date of reaping: 15/1/46—12/2/46
Date of first spraying: 6/12/45
Concentration of DDT in emulsion: 3%
Number of plants: 400
(treated 200
emulsion control 100
unsprayed 100)
Apparatus: (i) hand sprayer:
(ii) knapsack sprayer.
Deposit: 0.13 mg/cm²

TABLE I

PERCENTAGE OF PLANTS INFESTED WITH LARVAE OF *Ascia* (A) AND *Plutella* (B)

Date of inspection		DDT emulsion	Emulsion control	Unsprayed control
8/12/45	A	0	3	4
,,	B	0	58	55
16/12/45	A	0	11	19
,,	B	0	78	82
24/12/45	A	0	14	19
,,	B	0	100	100
All plants sprayed 28/12/45 and 18/1/46.				
5/1/46	A	0	0	0
,,	B	0	0	0
30/1/46	A	0	0	0
,,	B	0	0	0

The clean growth made by the controls after January 5 enabled the heads to be marketed, but without this it is unlikely that 50% of the controls would have been fit for sale. The cost of material was 2s. 6d. and of labour (4½ man hours at 6d.) 2s. 3d. 8% of all plants failed to develop a head. Accordingly if the spraying saved only 50% loss i.e. 184 cabbages, these of an average weight of 6 lbs. at a market cost of 6d. per lb. would be worth £27. It is to be noted that a grower in St. Lucia reported 100% loss of crop in 1945 and 1946.

DDT v. *Plutella*
Date of planting : 1-4 10/45
Date of reaping : 10-20 12 45
Dates of spraying : 11/10 45 ; 27/10 45 ; 18/11/45
Concentration of DDT in emulsion : 2%
Deposit : 0.095 mg/cm²
Apparatus : knapsack sprayer
Number of plants : 200 in two 1/8 acre plots
Number of plants treated : 100

TABLE II

PERCENTAGE OF PLANTS INFESTED WITH LARVAE OF *Plutella*

Date of examination	DDT sprayed	Unsprayed
11/10/45 (before spraying) ...	—	74
15/10/45	0	88
26/10/45	2	100
18/11/45 (before re-spraying) ...	5	100
10/12/45	21	100

The late infestation of the sprayed cabbages was confined to the outermost leaves near the ground. The lower surface of these had not received spray for two months as the later applications were directed on to the developing head, and the leaves wrapping the head. All the sprayed heads were marketed, while 37% of the unsprayed were not picked even for domestic use.

It is undoubtedly occasionally possible in Antigua to grow a plot of cabbages without the necessity of using insecticides. But sustained absence of *Plutella* and *Ascia* even from small and isolated plots of cabbage is exceptional, and the commercial grower should regard heavy infestation as a normal contingency and be prepared to meet it.

DDT v. *Ascia monuste* (L.) on turnip
Number of plants : 400 closely spaced
Apparatus : hand sprayer
Date of spraying : 14/12/45
Number of leaves counted : sprayed, 1158 ; unsprayed, 975
Number of plants sprayed : 225
Number unsprayed : 175 in three transverse strips across each end and middle of plot.

TABLE III

Date of Inspection	%plants with egg-clusters		%egg-clusters not hatched	%leaves eaten by larvae	
	sprayed	control		sprayed	control
16/12/45	70	66	13.8	0.17	34.1
5/1/46	51	69	9.1	0.69	47.5

The difference between the percentage leaves eaten in the sprayed and unsprayed plots is significant at P=0.01.

The second figure for percentage of leaves eaten in the sprayed plot includes damage seen at the first inspection, some of which was caused before the spray was applied. The same procedure was adopted for the unsprayed plot, but here the totals approximately represent current infestation, as the leaves entered on the first count had in large part disappeared before the second.

DDT v. Beet Webworm
Number of plants treated : 200
Number of control plants : 200
Apparatus : Hand sprayer
Dates of spraying : 8/1/46 ; 16/1/46
Concentration of DDT : 2%
Deposit : .095 mg/cm²

TABLE IV

Date of examination	Percentage of plants showing leaf damage		Number of larvae collected from plants	
	sprayed	control	sprayed	control
16/1/46	1.5	36.0	3	79
25/1/46	4.5	69.5	7	143

On approximately 10% of infested leaves two larvae were present. The cost of material was 4½d. and the cost of application (1 man for two 25-minute periods) 6d.

The differences between the percentage of leaves eaten in the two plots, and between the numbers of larvae collected are both significant at the 1 per cent. point.

DDT v. *Anticarsia gemmatalis* Hubn. on Soy Bean
Number of plants treated : 530
Number untreated : 240
Apparatus : Myer's knapsack sprayer
Concentration of DDT : 4%
Deposit : 0.17 mg/cm²
% plants infested before spraying : 9.3

TABLE V

Date of inspection	Percentage of plants attacked	
	4% spray	control
8/1/46	9.6	78.3
18/1/46	11.5	92.9

The second totals include the first. The differences are significant at the 1 per cent. point.

The yields of the plots, however, as compared from sample pickings of four rows, were not significantly different. This was attributed to the advanced stage of growth before attack began and to the comparatively moderate degree of oviposition. When *Anticarsia* suddenly appears on a crop it is not possible to forecast the ultimate severity of attack at the time when a decision whether or not to spray has to be taken. The cost of the trial, 3s. 6d. for materials and 3d. for labour, was accordingly not recovered.

It is worth adding that for control of *Anticarsia* the common practice of spraying with a suspension of lead arsenate is entirely effective, as was well shown by the arrest of a major attack at Piccadilly Agricultural Station by this means. When lead arsenate is applied to leguminous crops in the Lesser Antilles its concentration should not exceed 1½ lbs. to 50 gallons.

DDT v. *Heliothis armigera* Hubn. on cobs of Maize
Size of plot : 0.05 acre.
Spacing of plants : 16" x 28"
Date of application of treatment : 7/12/45
Treatments : DDT emulsion 1% (maximum deposit : .04 mg/cm²) ; DDT dust in cryolite 10% ; removal of silks by cutting at point of emergence.
Percentage silks with eggs at date of application : 69.1
Number of cobs per treatment : 100

TABLE VI

PART I.—PERCENTAGE OF COBS ATTACKED BY LARVAE OF *Heliothis*

Date	Sprayed	Dusted	Silks cut	Control
12/12/45	61	44.9	41.6	70.2
17/12/45	67.5	49.0	73.1	80.7

PART II—PERCENTAGE OF COBS WITH INCOMPLETE SEED SET

Date	Sprayed	Dusted	Silks cut	Control
30/12/45	27	4	14	5

The following points emerged from observation of this experiment : (1) DDT emulsion at 1% caused rapid and almost complete withering of the exposed portion of the silks. This resulted in a loss of seed (owing to non-fertilisation) fully comparable in its severity with that caused by insects ; (2) the DDT-cryolite dust caused no injury, but application was limited to the outer layers of the silk : this meant that larvae travelling along the middle of the silk were not exposed to a lethal dosage ; (3) cutting of the silks was largely stultified by the facts that in early-extruded silks a larva had already passed beyond the point of severance, while newly-extruded silks were removed before the pollen tube had grown down into the ovaries : moreover, after a few days larvae began to hatch from eggs which had been laid on the cut surface of the silk or at the entrance to the cob.

In wet or humid weather rotting of cobs frequently follows insect attack. If in the present experiment this had occurred, the amount of marketable grain saved would have been more than sufficient to pay for the treatment. As it happened the unbitten grains in the infested cobs dried out to give marketable seed, so that the difference in the number of cobs damaged does not necessarily reflect a corresponding difference in the amount of corn sold from the respective plots.

DDT v. Green Bug (*Nezara*) on tomato
Number of fruit on treated plants : 1,515
Number of fruit on untreated plants : 520
Layout : 2 plots of 17 rows each, side by side
Concentration DDT : 2%
Deposit : 0.1 mg/cm²
Dates of spraying : 1/11/45 ; 16/11/45 ; 22/12/45; 3/1/46 ; 8/1/46
Apparatus : knapsack sprayer

TABLE VII

DISTRIBUTION OF *Nezara* ACROSS PLOTS : NUMBER OF INSECTS (derived from average of 4 counts of *Nezara* on fruit)

Row number	Field 1 (unsprayed)	Field 2 (later sprayed)
1	13.25	8.0
2	2.25	6.5
3	8.5	5.75
4	1.5	5.5
5	2.75	3.5
6	2.25	0.25
7	1.5	2.9
8	0.5	0.0
9	0.0	2.25
10	0.25	1.25
11	1.5	0.0
12	1.25	3.75
13	6.25	2.5
14	0.75	3.5
15	2.5	5.75
16	11.0	14.25
17	8.0	9.75

The plots at each end adjoined pasture with many host weeds, while on the outer side of each plot lay unplanted land or maize. It is evident from Table VII that immigration from the pasture and weed growth at the ends was important. The difference between the totals for the three rows at each end and the remainder is highly significant.

The difference between the number of infested fruit on each plot (Table VIII) is significant at the 1 per cent. point. The total—the percentage representing the number of fruit infested in cumulative attacks—is based on the assumption that no fruit has been found with *Nezara* on it more than once. The percentage of *Nezara* in the nymphal stage observed on the treated plots in the last two counts was less than one ; in the untreated plots the percentage of the population represented by nymphs was 74.

The decreasing percentages of the treated plot reflect the fall in the insect population; such insects as were counted may well have been largely composed of recent immigrants, whereas the control plot would have both recent and older immigrants.

TABLE VIII

PERCENTAGE OF FRUIT ON WHICH GREEN BUG WAS COUNTED

Date :	31/10/45	15/11/45	21/12/45	2/1/46	7/1/46	14/1/46	Total
Treated plot	—	6.1	6.0	4.2	0.75	0.15	30.5
Control	13.3	13.0	9.2	15.1	9.8	10.1	70.2

The percentage of fruit rendered unmarketable by a given population of *Nezara* depends on the dispersion of its members : three nymphs may be found on a single fruit, while three adults may each attack a different fruit. The loss caused by *Nezara* in this experiment is approximately given by the total of damaged fruit less the number damaged by grasshoppers (*Schistocerca*) and birds, though fruit in the latter category may also have been damaged by *Nezara*.

TABLE IX

ANALYSIS OF DAMAGED FRUIT

	Number of fruit counted	Number damaged	No. damaged by grasshoppers and birds	Number damaged by *Nezara*
Sprayed	1,515	166	23	143 (9.4%)
Control	520	97	16	81 (15.6%)

The 6.2% of fruit saved represents a difference significant at the 1 per cent. point.

In this experiment no account has been taken of fruit which may have dropped after being damaged in an early stage of growth. Furthermore the early damage inflicted by *Nezara* present on each plot before spraying was begun (more than 60 per plot) would account for a proportion of the final damage recorded. It is evident from the results that this could have been reduced by earlier application of the spray.

Tomatoes for local consumption are allowed to ripen in the field and culls can be rejected on picking. When fruit is picked at an unripe stage for shipping to distant markets it is not possible to cull efficiently, since at picking the fungal infestation following puncturing by *Nezara* is not apparent, and fruit are shipped as sound which are unmarketable when they reach their destination. This hazard can clearly be greatly reduced by routine application of DDT to the crop whether it is infested with *Nezara* or not. The cost per acre in the above experiment was £1. 3s. 0d. for materials and 5s. 0d. for labour, which would be recovered if some 250 fruit per acre were saved.

An attempt was made to treat a plot of tomatoes with 10% DDT in cryolite. Much of the DDT was nodular or coarsely granular and even after simple pulverisation did not appear on mixing to disperse effectively through the cryolite. Examination of particles revealed the presence of a high proportion of minute crumbs of DDT coated with cryolite. The mixture was placed in coarse cotton bags 30 cm. x 12 cm. and was applied by holding the bag close to the plant on the windward side and tapping it smartly once or twice with a short stick. The texture of the powder thus sifted was satisfactory. Nevertheless it was found that even in a slowly-moving air current wastage was high and adhesion to the lower surface of fruit was poor. The application was repeated after 48 hours and counts of *Nezara* were made at two day intervals. The number of insects observed did not show any significant difference from that counted in an adjacent control plot.

The view is held that the particles of DDT as applied were insulated by a coating of cryolite, and did not come into contact with insects traversing them, as cage tests of pure DDT dust against *Nezara* have shown that the material is effective at 0.14 mg/cm^2. In any future dusting the use of pure DDT dust or dust mixed with a diluent of equal particle size would appear advisable.

DDT v. *Solubea pugnax* (F.)

A further opportunity of studying the residual effect of DDT emulsion against Pentatomid bugs arose when a large population of *Solubea pugnax* developed on flowering Antigua Hay-grass (*Andropogon* sp.) in January 1946. This species, like others of the genus, feeds largely on developing grain. The numbers of the insect were immense, and the adults moved freely in short flights. It was evident that any effectiveness of DDT residue against adults would be masked, in a small area, by the influx of numerous immigrants. This consideration was of far less importance in the case of the wingless stages, and it was decided to limit observations to nymphs.

An area 12 yards x 12 yards was divided into four equal squares and diagonally opposite pairs received the same treatment. Counts were made on eight dates of nymphs on four plots, each a yard square, chosen at random in a 4 x 4 block in each square, each of these blocks situated two yards from the margin of the experimental area.

TABLE X

Date of spraying : 27/12/45. Deposited : 0.14 mg/cm². Concentration of DDT : 3% Apparatus : knapsack sprayer
c=control ; s=sprayed.

NUMBER OF NYMPHS OF *Solubea* PER PLOT

Date of count	28-12-45		1-1-46		4-1-46		7-1-46		10-1-46		13-1-46		16-1-46	
	s	c	s	c	s	c	s	c	s	c	s	c	s	c
1st & 2nd instar	16	9	8	24*	2	13	14	10	0	32*	11	3	0	0
	42*	15	11	6	9	25*	9	0	6	6	0	27*	5	9
3rd instar	0	0	1	1	0	12	3	6	8	7	0	22	5	17
	3	1	0	3	1	0	0	11	0	8	0	11	0	0
4th instar	1	0	1	2	0	1	0	7	0	3	1	4	6	3
	0	3	0	6	1	6	0	2	0	7	0	9	1	6
5th instar	0	0	0	1	0	2	0	0	0	2	0	1	0	0
	1	4	0	0	0	0	0	3	0	0	1	4	0	4

Total : Control : 358 Sprayed : 167

*This total includes a cluster of newly-hatched nymphs which had not begun to feed or disperse.

The difference between the treatments is significant at the 1 per cent. point.

The difference between the total of nymphs in each series does not bring out the effectiveness of the insecticidal residue. If nymphs of the first and second instar are left out of account, as having been reinforced by immigrants in the form of nymphs newly hatching from egg-clusters, the nymphal population of the sprayed plot is less than a fifth of the corresponding population in the control plots.

DDT v. Egg-plant Lace-bug

It has been established (Fennah, 1945) that in cage tests a high mortality occurred in a population of *Corythaica planaris* Uhl. which was exposed for 48 hours to a deposit of 0.15 mg/cm² of DDT.

At Cades Bay Settlement, Antigua, spray was applied on two garden plots containing fifteen and twelve eggplants respectively, all of which were infested with adults and early nymphal stages. The spray was applied to both leaf surfaces. The emulsion applied to the smaller plot was re-stabilised after dilution with the local hard water by the addition of twice as much soap as was necessary to restore the emulsion : that applied to the larger plot was merely diluted and was kept vigorously agitated while being applied. The object of the latter treatment was to determine whether vegetable-growers in the area could afford to dispense with the aid of the addition of extra soap.

DDT v. *Corythaica*
Date of spraying : 7/9/45
Concentration of DDT : 3%
Deposit : 0.14 mg cm²
Date of inspection : 11/10/45
Emulsion on plot A stabilised ; emulsion on plot B not stabilised, but agitated.
Apparatus : knapsack sprayer
Number of plants treated : plot A, 10 ; plot B, 10.
Number of unsprayed controls : plot A, 2 ; plot B, 5

TABLE XI

	Plot A		Plot B	
	Treated	Control	Treated	Control
Percentage of leaves infested ...	34	88	92	94
No. of insects per sq. cm. ...	0.3	2.9	4.2	3.9
Percentage of leaves scorched by spray	0	—	74	—

The number of insects per sq. cm. was obtained by averaging the population counted on 4 sq. cm. samples taken in the basal third of twenty mature leaves selected at random. The difference between the leaf infestation on the sprayed part of plot A and that of all the other plots is significant at the 1 per cent. point, as is the difference between the average number of insects per sq. cm. on this area and that on all other plots. The treated portion of plot B is not significantly different from the controls in either plot.

All the plants which received the agitated unstabilised emulsion later showed severe leaf scorching where the white and greasy droplets of spray had alighted. Beneath the leaves and among the scorched patches a considerable population of *Corythaica* developed. It was known that the spray cover was uneven, and it is presumed that the insects avoided the scorched areas by their sense of smell. The effect of their feeding was so marked that very little of the surface of mature leaves

remained green in the unscorched areas. The plot which had received the stabilised emulsion stood out in marked contrast to all the remainder, as on this alone the plants were of normal colour. It is nevertheless to be noted that these, in common with the remainder, were showing the effects of high water stress (the weather being dry) so that an optimal yield of fruit was not assured merely by the removal of the lace-bug population. In view of repeated observations that *Corythaica* in the Lesser Antilles develops in large numbers when other factors are present which limit normal development of the host, it is unlikely that spraying alone will result in the yield expected by the grower. If, as is believed, the conditions which impede growth by the plant indirectly promote the development of *Corythaica* there is need for a more fundamental approach to the problem with the aim of readjusting this relationship by treatments which will affect both plant and lace-bug.

The considerable development of the insect population on leaves which had been incompletely sprayed and had become scorched where the spray alighted is of some interest as it appears to afford a parallel to the development of an aphid population on turnips which occurred in the following experiment.

DDT v. *Aphis gossypii* Glov. on turnips

A bed of closely planted turnips 24 ft. x 3 ft., infested with *Aphis gossypii* Glov. was divided transversely into two equal areas. On one plot (A) DDT was applied to the upper surface of the leaves only, while on plot (B) it was applied to both leaf-surfaces.

TABLE XII

Number of plants treated : plot A, 300, plot B, 300.
Concentration of DDT : 3%
Deposit : 0.14 mg cm^2
Date of spraying : 22 12 45
Apparatus : hand sprayer
Percentage of plants with leaves collapsed at beginning of experiment : <1

Percentage of Plants with Leaves collapsed

Date of inspection	23/12/45	8/1/46	15.1.46	25/1/46
Plot A	<1	86	100	—
Plot B	0	<1	6	79

The difference between the percentages in the two plots is significant at the one per cent. point. The contrast between the two plots was very striking, the leaves which had received the spray on both surfaces being turgid and green, while those in the other plot were collapsed and shrivelled. The difference is explained by the fact that the aphids, notwithstanding some degree of wandering, fed to a very large extent on the lower side of the leaves, and accordingly did not come in contact with the residue on the upper surface.

The insects in plot (B), where both leaf-surfaces were sprayed, were largely destroyed by contact at the first application of the spray. Nevertheless even on these plants small reproductive units were left untouched in convolutions of the leaves. These continued to develop, though for some time many nymphs were destroyed as they attempted to colonise the sprayed areas. Later, however, the spray residue lost its toxicity and the aphid population was able to spread generally over the lower leaf surface. During the period when the residue was toxic to the aphids no insect predators, such as coccinellid beetles or syrphid flies, were able to survive exposure to the DDT and accordingly did not contribute to the control of the aphids.

The changes in the aphid population on the general lower leaf-surface are shown in Table XIII.

TABLE XIII

Sample : 50 mature sprayed leaves per plot.
Average leaf area : 178 cm^2

Mean Number of Aphids per Leaf

Date of sampling	23/12/45	8/1/46	15/1/46	25/1/46
Plot A	35.1	57.8	—*	—
Plot B	2.8	6.4	20.4	49.8

* In this plot at this date only a few small centre leaves remained on the plants.

The differences in the first two columns are significant at the one per cent. point.

The reason for the apparent loss of toxicity of the deposit is not known, but it is clearly of considerable importance. As DDT is comparatively stable the diminished toxicity is most reasonably to be attributed to erosion by rain or to masking by a further deposit. During the period of the experiment there were several showers of rain. It was noted that the underside of the older leaves was bespattered with soil, and it is possible that the deposit below the leaves may have become overlain with a microscopic sediment of clay particles. This factor, however, even if its effect be admitted, could not have been responsible for the reduced toxicity of the residues on the inner and less exposed leaves.

It is evident from Table XII that 3% DDT emulsion is effective as a contact spray against aphids : its residual effects, which on crinkly-leaved plants are likely to operate more effectively against predators than against the pest, may do more harm than good. The grower who wishes to combat aphid attack is advised to use a contact spray which leaves no toxic residues : for this purpose nicotine sulphate or derris extract is suitable.

An outbreak of the Aphid *Toxoptera aurantii* on terminal shoots of *Gliricidia maculata* at the Botanic Gardens, St. Johns, provided material for comparison of DDT emulsion at a concentration of 0.5% and of nicotine sulphate at 0.125%. Fifty shoots, each completely encrusted with aphids, were lightly sprayed

with an atomising sprayer with one of the two insecticides, and were appropriately labelled. Four shoots of average size and infestation were removed and dropped in spirit and the average number of aphids per shoot was determined : this was 106. The sprayed shoots were examined 12 hours later and all were found to be quite free from insects.

DDT v. leaf-mining Diptera

In the treated and untreated plots of cabbage used in the trials of DDT against *Ascia* and *Plutella* it was possible to estimate the effect of the treatment on the incidence of the cabbage leaf-miner, *Liriomyza pusilla* Meig. Similarly, in a plot of onions on which DDT was tested against onion thrips (discussed below) observations were made on the relative incidence of *Liriomyza pusilla* and a species of *Agromyza* near *flaveola* Fall. Neither of these insects been known to attain the status of a serious pest in the Lesser Antilles.

TABLE XIV

Treatment data as in Table I.
Number of mature leaves examined :
Sprayed, 1,000
Control, 200
Dates of inspection : 16/12/45 ; 27/12/45

Incidence of *Liriomyza* on Sprayed and Unsprayed Cabbage

	Sprayed	Control	Sprayed	Control
Percentage of leaves with a mine ...	<1	2	1.3	12.5
Total number of leaf-mines	8	11	17	315
Greatest number of mines per leaf ...	2	4	2	5
Average number of mines per mined leaf	1.14	2.75	1.30	1.22

The difference in the number of leaves mined and the total number of mines per plot between the two plots is highly significant in both experiments (Tables XIV and XV).

The reduction in attack by these species would appear to be due to mortality of adults before oviposition.

On the above plot of onions an incipient attack of onion thrips (*Thrips tabaci*) was noted and a trial was instituted to determine the effectiveness of a spray of DDT emulsion. Two hundred leaves were collected at random and the number of linear scarifications on them was counted. These scarifications are the result of damage to leaf-cells by feeding of the onion thrips. Their average density per leaf was 9.6. As a measure of the scale of attack in its early stages a count was made of the number of leaves bearing ten or more scarifications of 5 mm. length or longer on two groups of eighty plants, a group from each plot, the plants of each group being chosen at random from ten successive rows near the middle of the plot. The number of plants was selected to give a total of approximately 1,000 leaves.

The relative incidence of thrips on the two plots is shown below.

TABLE XVI

DDT v. *Thrips tabaci* Lind.
Size of plot : sprayed : 1/9 acre ; control : 1/9 acre
Concentration of DDT : 3%
Deposit : 0.14 mg/cm²
Apparatus : knapsack sprayer
Date of spraying : 14/12/45
Date of counting : 18/1/46

Incidence of Damage done by Thrips on Onion Leaves

	Sprayed plot	Control plot	Difference
Number of leaves with scarifications ...	97	361	264
Number of leaves free from damage ...	810	277	533

The differences between both totals for the two plots are significant at the one per cent. point.

The spray residue markedly checked the development of thrips attack. It was not possible to follow the prolonged effect on the rate of development as

TABLE XV

Treatment as in Table XVI
Number of leaves examined : sprayed, 1,000 ; control, 1,000
Incidence of *Liriomyza* and *Agromyza* on sprayed and unsprayed onions

Date	16/12/45		27/12/45		18/1/46	
	sprayed	control	sprayed	control	sprayed	control
Percentage of leaves with a mine	2.1	2.1	3.4	19.7	4.8	27.2
Total number of leaf-mines	29	21	36	21.8	55	30.2
Greatest number of mines per leaf	1	1	2	2	3	2
Average number of mines per mined leaf ...	1.0	1.0	1.1	1.1	1.1	1.1

the onions, which had matured, were lifted soon afterward. Outbreaks of thrips on the crop in its early stages may be disastrous. It is clear that a spray of 3% DDT emulsion applied at the first signs of attack can be expected to afford protection for about a month. The spraying should be repeated if there are indications of reintensification of attack. The cost of spraying onions is very low, owing to the narrow distribution of foliage and the relatively high rate of progress of the operator. A plot covering one third of an acre was sprayed by a single operator at a cost of 11d. (8d. materials, 3d. labour).

CONCLUSIONS

The results of the experiments show that DDT at the weights of deposit given was lethal to the insects against which it was used. Its effectiveness, however, depended on the extent to which it was brought into contact with the pest. This was greatest where the cover of DDT residue was complete and exposed, and was least where it was interrupted or masked. An exceptional combination of interfering factors occurred in the plot of turnips used in the trial of DDT against *Aphis gossypii*: the leaves were crinkled and, owing to close spacing of plants, densely intermingled; the lower surfaces of the outer leaves were near the ground and were exposed to drifting dust or particles carried up in splashing raindrops.

The failure, as a contact insecticide used against *Nezara*, of a 10% DDT and cryolite dust is attributed to the disparity in size of the particles of the components: it was observed that comparatively coarse granules of DDT were coated with the finely-ground cryolite. The comparative success of the dust when used against *Heliothis* may have resulted from ingestion of particles by the larvae, when both components would operate as stomach poisons.

DDT emulsion, in combining the properties of a direct contact poison, a residual contact poison and a stomach poison, is effective against a wide range of food-crop pests, and in view of its extremely low toxicity to man and to stock is well suited to the needs of the small cultivator. It is very easy to prepare, but as with other insecticides for field use, it is not kept in stock locally, and its materials at present have to be imported by the prospective user.

In spite of the exceptional qualities of DDT, its suitability in any particular case must be assessed in relation to that of two specialised and locally well-known spray materials—arsenical stomach poisons and contact poisons containing nicotine or rotenone.

Lead arsenate suspension or a dust of Paris green mixed with lime may be used to combat an attack by caterpillars on leaves not liable to scorch and not intended for human consumption. Contact sprays of nicotine sulphate or derris extract are suitable where immediate and direct contact with the pest is assured. In such circumstances they are potentially as effective as DDT.

SUMMARY

Aqueous dilutions to a concentration of 2-4% DDT of a stock emulsion comprising DDT 15%, tetralin (tetrahydronaphthalene) 26%, Triton B 1956 4%, soap 0.4%, and water 54.6% were found effective in field trials conducted in Antigua, B.W.I. when applied to give a deposit of 0.04-0.17 mg. DDT/cm^2 against *Ascia monuste* (L.) (Pieridae), *Plutella maculipennis* Curt. (Hyponomeutidae), and *Liriomyza pusilla* Meig. (Agromyzidae) on cabbage, *Zinckenia fascialis* Cram. (Noctuidae) on soy bean, *Nezara viridula* (L.) and *Solubea pugnax* (F.) (Pentatomidae) on tomatoes and *Andropogon* respectively, *Corythaica planaris* Uhl. (Tingidae) on eggplant, *Agromyza* sp. and *Liriomyza pusilla* Meig. (Agromyzidae) and *Thrips tabaci* Lind. (Thripidae) on onions, and *Toxoptera aurantii* Boyer (Aphididae) on *Gliricidia*.

A measure of success was obtained with a 10% DDT and cryolite dust against *Heliothis armigera* Hubn. (Noctuidae) on silks of maize. DDT emulsion containing 1% DDT scorched the silks and caused a significant reduction in setting of grain.

A spray of 3% DDT emulsion applied to both leaf surfaces on closely-planted turnips proved more effective against *Aphis gossypii* Glov. (Aphididae) than when applied to the upper surface only, but after three weeks failed to retard multiplication of the pest. This result is tentatively attributed to reproduction by aphids living within folds of the leaves while the spray deposit was progressively eroded by rain or masked by accumulation of dust particles.

REFERENCE

Fennah, R. G. 1945, Preliminary Tests with DDT against Insect Pests of Food-crops in the Lesser Antilles. *Tropical Agriculture* 22: 222-226.

NOTICE TO SUBSCRIBERS

We desire to apologise for the delay in the appearance of this 1948 omnibus number of "Tropical Agriculture". Through difficulties both of staff and printers, it has been quite impossible to print the Journal on a regular basis. With the completion of the 1948 volume, arrangements have been made for the reorganization of the Publications Department of the College and every endeavour will be made during the present year to catch up with arrears.

It is hoped to issue the Journal on a half-yearly basis during 1949 and to resume publication on a monthly basis in 1950.

NOTES ON THE TERMITE FAUNA OF THE LESSER ANTILLES

BY

A. M. ADAMSON

The following paper was prepared by the late Professor A. M. Adamson and is published with a few minor alterations.—(Ed.)

Introduction

In an earlier paper (2) a short report was given on the termites responsible for damage to buildings in the Lesser Antilles, based on collections and observations made during brief visits to many of the islands. The present paper deals with the termite fauna as a whole. The islands of Trinidad and Tobago are not included, because they belong to the Brazilian and not to the Antillean sub-region, having faunas very different from those of other West Indian islands. Reports (1, 3) have already been published on the termites of Trinidad.

My collections of Antillean termites have been enriched by specimens received from various collectors. I wish to thank especially Mr. R. W. E. Tucker in Barbados, Mr. R. G. Fennah in St. Lucia and Mr. C. G. Munro in Grenada for sending me much interesting and valuable material.

Beyond a few scattered records, scarcely anything has been published on the termites of the Lesser Antilles. The material on which this report is based is somewhat meagre and very unequal as regards the several islands, but the essential facts regarding the most destructive species — in the genera *Cryptotermes, Heterotermes and Coptotermes* — are known for the area as a whole. The termites of Barbados have been collected fairly extensively, thanks to the work of Mr. Tucker, and probably only a few species remain to be discovered. While visiting St. Vincent in June 1938 I was able to devote part of a week to the study of termites, and made a collection that is at least representative. But in all the other islands very few collections have been made and little more than a guess at their complete termite fauna can be attempted. It may be mentioned that relatively little work has been done on the termites of the Greater Antilles. In Puerto Rico, Wolcott has studied the habits of some of the most destructive species and gives a list (4) of some 15 species occurring in the island. In Jamaica, Edwards has written on the destructive species and their control, but further work on the termites of Jamaica should be undertaken. From Cuba, Haiti and Santo Domingo comparatively little information is available.

The termite fauna of the Lesser Antilles, excluding Trinidad and Tobago, is relatively poor for the tropics. Only one species of the largest and most highly evolved family of termites, the Termitidae, is recorded as a conspicuous member of the fauna of all the islands. This is *Nasutitermes costalis* (Holmgren), the dominant termite throughout the West Indies. On St. Thomas, U.S. Virgin Islands, judging by a few hours' visit, its place seems to be taken by *N. acajutlae* (Holmgren). *Heterotermes tenuis* (Hagen), abundant and destructive though inconspicuous, has been found on all the islands where a search has been made. Apart from these two dominant species, the destructive domestic termite, *Cryptotermes brevis* (Walker), and the genus *Coptotermes* in Barbados and Grenada, the termites of these islands are scarcely noticed except by those who set out to study them.

LIST OF LESSER ANTILLEAN TERMITES

BARBADOS

1 — 2. *Kalotermes* spp.
3 — 4. *Neotermes* spp.
5. *Cryptotermes brevis* (Walker)
6. *Cryptotermes* sp.
7. *Heterotermes tenuis* (Hagen)
8. *Coptotermes havilandi* (Holmgren)
9. *Rhinotermes marginalis* (L.)
10. *Nasutitermes costalis* (Holmgren)

GRENADA

1. *Kalotermes* sp.
2. *Neotermes* sp.
3. *Cryptotermes brevis* (Walker)
4. *Heterotermes tenuis* (Hagen)
5. *Coptotermes testaceus* (L.)
6. *Nasutitermes costalis* (Holmgren)

ST. VINCENT

1. *Kalotermes* sp.
2. *Neotermes* sp.
3. *Cryptotermes brevis* (Walker)
4. *Glyptotermes* sp.
5. *Calcaritermes* sp.
6. *Heterotermes tenuis* (Hagen)
7. *Nasutitermes costalis* (Holmgren)

ST. LUCIA

1. *Neotermes* sp.
2. *Cryptotermes brevis* (Walker)
3. *Nasutitermes costalis* (Holmgren)

MARTINIQUE

1. *Heterotermes tenuis* (Hagen)
2. *Nasutitermes costalis* (Holmgren)

DOMINICA

1. *Nasutitermes costalis* (Holmgren)

GUADELOUPE

1. *Heterotermes tenuis* (Hagen)
2. *Nasutitermes costalis* (Holmgren)

ANTIGUA

1. *Nasutitermes costalis* (Holmgren)

ST. KITTS

1. *Nasutitermes costalis* (Holmgren)

ST. THOMAS

1. *Heterotermes tenuis* (Hagen)
2. *Nasutitermes acajutlae* (Holmgren)

ST. CROIX

1. *Nasutitermes acajutlae* (Holmgren)

NOTES ON LESSER ANTILLEAN TERMITES

Nasutitermes costalis (Holmgren)

This is one of the commonest builders of "carton" nests on trees and other sites above the ground throughout the West Indies as well as in many parts of South America. With *Heterotermes tenuis* it is the dominant species of termite in the Lesser Antilles, though in St. Thomas its place seems to be taken by *N. acajutlae*. Wolcott reports serious injury to buildings in Puerto Rico by *N. costalis*, and Edwards records similar damage in Jamaica by "*Nasutitermes rippertii*". Although *N. costalis* is undoubtedly capable of attacking wood in buildings, I have found it to show a marked preference for wood which has begun to decay. In Trinidad and other islands I have rarely found it attacking buildings other than those which had been almost abandoned or to the maintenance of which scarcely any attention was being paid.

Nasutitermes acajutlae (Holmgren)

This termite builds very large and conspicuous arboreal "carton" nests similar to those of *N. costalis*. It is recorded widely throughout South America and in Trinidad is a common member of the termite fauna. This is the only species of the genus that I have collected in St. Thomas, U.S. Virgin Islands, but it does not appear to have been found as yet in the intervening islands, such as St. Vincent and Barbados. It may be present, however, in these islands, though less common than *N. costalis*.

Cryptotermes brevis (Walker)

This is the common dry-wood termite throughout the West Indies. It infests buildings and furniture and appears to be an entirely domestic species. I know of no record of its occurrence outside buildings. Its status in the Lesser Antilles is probably the same as in Trinidad.

Heterotermes tenuis (Hagen)

As already discussed (2) this is the common and very destructive subterranean termite of the islands in the Lesser Antilles where it has been studied. It is a highly variable species, and, although some of the variation may be of an insular character, separation into more than one species does not appear to be justified. To the records I have already published, I would add that of several large series of alates, taken with soldiers and workers, in Barbados and sent to me by Mr. Tucker. These agree well with alates of this species in Trinidad.

Coptotermes havilandi (Holmgren)

The most interesting, if disquieting, of recent records of termites in the West Indies is that of the very destructive Oriental species, *Coptotermes havilandi*, in Jamaica and Barbados. The species of *Coptotermes* are probably the most destructive of all termites in the tropics. Dr. A. E. Emerson (1940, *in litt.*) states that *C. havilandi*, hitherto known only from the Malayan subregion, was also introduced into Mauritius at some time prior to 1870, but that the indications are that the introductions into Jamaica and Barbados are fairly recent. Dr. Emerson records also the introduction of *C. formosanus* Shiraki to South Africa. A native of the Oriental region like *C. havilandi*, it has also invaded the Hawaiian Islands, where it is the most destructive termite and has caused great economic loss. It is apparent that members of the genus *Coptotermes* are capable of being accidentally introduced over very great distances and of becoming serious pests in new countries. The suggestions already offered (2) regarding quarantine precautions against the further spread of this genus in the West Indies are more than justified by the discovery of this important immigrant species from the Orient.

Coptotermes testaceus (L.)

Notes on the economic status of this species in Trinidad have already been published (1). Its discovery in Grenada is apparently due to Mr. C. G. Munro, who originally sent me material and with whom I was able to examine an infestation in June 1938.

Neotermes sp. n.

In 1938 I collected a large and striking species of *Neotermes* at three localities in St. Vincent and I have received also specimens from Grenada and Barbados. Dr. A. E. Emerson

(*1943, in litt.*) states that it is quite certainly a new species. In Grenada it is believed to injure live cacao trees. The question of whether it invades living tissues, or whether it merely follows other agents of decay into dead wood, has not been studied.

Neotermas sp.

A large species of *Neotermes*, near to *N. holmgreni* Banks but possibly undescribed, is common in Barbados. I have found the same species commonly in Trinidad.

Kalotermes sp.

A large and striking species, probably undescribed, which is common in Trinidad, appears in collections from Barbados, Grenada and St. Vincent.

Calcaritermes sp.

No members of this genus of small and inconspicuous dry-wood termites appear to have been recorded from the Lesser Antilles. I found a single colony of an undetermined species, possibly new, in St. Vincent.

Glyptotermes sp.

This genus, like *Calcaritermes*, has not been previously recorded from the Lesser Antilles and I have found only one species, probably new, in St. Vincent.

REFERENCES

1. Adamson, A.M. (1937) Preliminary report on termites and termite damage in Trinidad, West Indies. *Trop. Agriculture, Trinidad* 14 : 141 – 149.

2. Adamson, A.M. (1938) Notes on termites destructive to buildings in the Lesser Antilles. *Trop. Agriculture, Trinidad* 15 : 220 – 2-mm m MM HM MM 220 – 224.

3. Adamson, A.M. (1940) A second report on the termites of Trinidad; British West Indies. *Trop. Agriculture, Trinidad* 17 : 12 – 15.

4. Wolcott, G.N. (1941) Supplement to Insectae Borinquenses. *Jour. Agric. Univ. Puerto Rico 25* : 41 – 43.

REVIEW :

THE PLANT IN HEALTH AND DISEASE, by W. A. R. Dillon Weston, M.A., Ph.D., Dip. Agric. and R. Eric Taylor, B.Sc., M.A. *(Pp. 173 + xii, frontispiece in colour, 60 half-tone plates, 6 text-figures). London : Crosby Lockwood & Son Ltd., 1948. Price 21/-.*

This book gives a well-balanced, general account of the science of Plant Pathology. It is not meant to be a comprehensive treatise on all the varied aspects of the subject, for more detailed consideration of which the reader is referred to other works. The book will be of particular value to agriculturists and horticulturists in the United Kingdom, as most of the diseases used for purposes of illustration occur there ; but it should also prove useful to workers in the tropics, where the same general principles apply. An early chapter gives brief notes on the physiology of green plants as a basis for the discussion on their pathology. The authors rightly emphasize the maintenance of plant health rather than the treatment of plant disease, but give an adequate general account of the various techniques suitable for fighting different pathogens. Of particular interest are the chapters dealing with seed-borne diseases and the prevention of many of them by seed treatment. The value, for this purpose, of organo-mercury dusts, which do not merely sterilize the seed but also protect it from re-contamination, is illustrated by a number of examples.

The standard of printing is high, and the numerous excellent plates are a feature of an attractive little book.

W.T.D.

REVIEW:

The Natural Vegetation Of Trinidad

BY

J. S. Beard, M.A., B.SC., D. PHIL.

10½ x 7½. Pp. 152 with 14 plates, 19 text-figures and one folding map in colours. Oxford Forestry Memoir No. 20, 1946. Clarendon Press, Oxford.

" The natural vegetation of Trinidad " starts with an account of the climate, topography and soils between which there is, of course, complex interaction. Briefly, the climate is a seasonal tropical one with a marked dry season; topography is varied and includes lowland plains, depressed swampy areas and mountains; soils are predominantly immature and, since they derive from a wide variety of parent materials, show a corresponding variety of structure and composition. There follows an account (with numerous tabular data, and some figures and plates) of the structure and composition of the natural communities along the lines now generally accepted for tropical ecological work. Fifteen formations are recognised, classified in two series, Climatic and Edaphic, according to physiognomy. Physiognomy and structure are related broadly with habitat, the latter being characterised especially by available soil moisture. This factor is considered to be of primary importance in the absence of limiting edaphic factors but is, of course, difficult to evaluate, arising as it does out of the interplay of rainfall seasonally distributed over a variety of soils of different structure on a variable topography. The great bulk of the vegetation is dominated by woody plants but some of the edaphic formations (swamp and marsh) are mainly or entirely herbaceous. In the last section (VI, p. 142), there is a useful discussion of dominance, as the concept applies to tropical vegetation, and an account of vegetational cycles in Trinidad and the North-eastern portion of South America of which Trinidad is geographically a part. It is suggested that savanna is an edaphic post-climax developed from climax forest by the plantation of topography (and consequent impedance of drainage), followed by the establishment of seasonally flooded marsh vegetation. The small areas of savanna at present found in Trinidad are to be regarded as " fossil " relicts of an extension of the Pleistocene land surface of Venezuela, the rest of the lowland savannas having been lost as a result of recent uplift and improved drainage.

Throughout the work most attention is paid to trees which, of course, form the bulk of the vegetation. Comment on the shrubs, vines, herbs and epiphytes is scanty though this was partly to be expected in view of our rather poor knowledge of some at least of the groups of plants concerned. A more serious deficiency is the rather sketchy treatment accorded to second growth, a series of communities of great practical and theoretical importance which are, incidentally, not properly known anywhere in the tropics. For the trees themselves, there are many useful notes on buttressing, flowering, fruiting, deciduousness, life-forms, etc., all material on which the autecological knowledge of the tree species essential to intensive forestry work may be based.

To sum up, " The natural vegetation of Trinidad " presents perhaps the most complete account we have of the vegetation of a tropical land. It achieves an integration which is not possible to more detailed studies of limited scope, valuable and essential as these are; at the same time it indicates the points at which intensive study may be expected to yield the most useful results. As a basis upon which our knowledge of an area of tropical vegetation may be advanced to the level commonly found in temperate countries this book is a notable achievement.

N.W.S.